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POPULAR SCIENCE REVIEW.

AMONG THE VOLCANOS AND GLACIERS OF AUVERGNE.

BY THE REV. W. S. SYMONDS, OF PENDOCK.

[PLATE I.]

IN Central France, as is well known, some very interesting volcanic phenomena are displayed in the country of the Auvergne and Ardèche. These volcanic phenomena must once have exhibited igneous activity upon the very grandest scale, and I have little doubt the igneous forces have been renewed from time to time from the eocene epoch of Sir Charles Lyell down to a comparatively modern period. Having visited this country now on three separate tours, in company with my friend Sir William Guise, and accompanied on the last occasion by Sir David Wedderburn and Mr. Lucy, members of the Cotswold Club, I would call the attention of our brother geologists, through the pages of the "Popular Science Review," to certain phenomena we thought worthy of stricter attention than it was in our power to give, and at the same time I will endeavour to give some information as to the best way of seeing, in succession, the grand displays of geological phenomena presented to our view. In the regions of the Mont Dore and the Cantal we find the relics of vast insulated volcanic mountains, like Mount Etna, which have been dormant for ages, and which everywhere exhibit proofs of the enormous denudation they have undergone since their lava streams flowed from their craters, or the lighter materials, such as scoriæ, pumice, tuffs, and volcanic ashes enveloped their cones. Atmospheric agencies, snows and frosts, streams and rivulets, and, in later times, the glacier, have utterly obliterated the volcanic cones, and these old miocene volcanos are laid bare even to their most inmost recesses.

Again, in the Chain of "Puys" near Clermont Ferrand, or the *Monts Dôme*, as also in those near the picturesque town of Le Puy in the Haute Loire, and near Vals, Montpézat, and Aubenas, in the Ardèche, we have examples of cones of igneous eruption which are of very recent date compared with the miocene volcanos of Mont Dore and the Cantal. Like the Vatna Jokull in Iceland, as described by Mr. Watts, the Monts Dôme must have formerly been a nest of volcanos, and the region around 'a country mourning in ashes and howling with desolation.' But comparatively recent as have been the volcanic outbursts of the Puys de Dôme, compared with those of Mont Dore and the Cantal, sufficient time has elapsed for streams to cut deeply into their most modern lava currents; vineyards cluster on their hill-slopes, beautiful woods grow in the rock gorges, and very old churches are built of the lava rock which once flowed in molten streams from their craters; while the fig tree bears its fruit where the ashes of the volcanos must have once darkened the air.

Before the geologist directs his attention to the district round Clermont Ferrand we recommend him to examine first the environs of *Moulins*, where are displayed the most northerly extensions of the sediments of that great freshwater lake of La Limagne d'Auvergne, whose waters once extended from Moulins in the north to Brioude, near Le Puy, in the south. Moulins itself is a quaint old place, through which the Allier flows wide and free, a very different stream from what we behold it when rushing among the hills of the Haute Loire. The great plain of the ancient fresh-water lake widens out as we proceed southwards, and in the summer-time green vineyards cover the lower slopes of the hills which rise above it. *Gannat* also requires especial attention on the part of the geologist, for both here and at Moulins there are indications of tertiary beds older than those in the Clermont Ferrand country. The Gannat beds furnish vast numbers of the thin shells or valves of Cyprides, small crustaceans which lived in millions in the waters of the ancient lake. Mammalian relics, too, are found in the basement strata at Gannat, Moulins, and Le Puy en Velay, which belong to eocene genera, for among them are those true eocene animals, the Palæotherium and Hyænodon, which occur also in the eocene strata of Hampshire and the Isle of Wight. Again, we have to account, as Mr. Scrope has pointed out, for the difference of level in the freshwater beds towards the north at Moulins, and southward near Issoire, where they attain a height of 2,700 ft., while the elevation north of Moulins is below 1,000 ft. I imagine that the Moulins country was depressed, and that the miocene beds above the eocene have there been denuded.

At *Aigueperse* a higher series of strata overlies the Gannat

beds, and these would seem to be of miocene age, as they have yielded bones of miocene animals. As far as I understand, the Aigueperse beds are overlain by the indusial limestone, which is characteristic of Gergovia and other localities near Clermont Ferrand, and which is so termed from the abundance of the cases (or *indusiæ*) of ancient caddis worms which enter into its structure. These cases were once the abode of the larvæ of a kind of fly (*Phryganeæ*) which frequented the waters of the miocene lake in shoals. Around the tubes of the caddis worms are attached numerous minute freshwater shells (*Paludinæ*, &c.) which the caddis worms when living agglutinated to their tubes.

Clermont Ferrand is an excellent place for head-quarters, from which to visit many localities of high interest in Auvergne, especially as it now is possible to go to some of the best stations by rail at a small expense. The town itself is full of interest in respect to archæological lore. Here Peter the Hermit preached religious war against the Saracens, and here Pope Urban elevated the cross before the multitude, maddened by that religious enthusiasm which sent thousands to die in a distant land, "far o'er the waters of the dark-blue seas." The "Dieu le Volt" of that vast host must have re-echoed from hill to hill; while hundreds thronged within the walls of Notre Dame du Port, which still stand as massive as in the days of the Hermit. Here the Pope Alexander III. thundered forth his blasting excommunications against the Emperor Barbarossa. Again, Clermont Ferrand was the birthplace of the illustrious Pascal, who will be remembered long after Pope and Emperor shall be forgotten. Pascal was the first philosopher who established the law of atmospheric pressure at different elevations, but his experiments were interfered with by the Jesuits at the College of Clermont, who threatened him with charges of heresy; as he says in his "Pensées," "Les Jésuites concluent toujours que leurs adversaires sont hérétiques." In consequence of this persecution, Pascal had to employ his brother-in-law, M. Périer, who lived at Clermont, while he sought refuge in Paris, to carry out his experiments and take a barometer to the summit of the Puy de Dôme. It was thus that in September 1648 the effects of atmospheric pressure were established beyond all doubt; while this present summer of 1876 witnessed a concourse of representatives of all the nations of Europe, assembled round the noble observatory erected to Pascal's memory on the Puy de Dôme, a grand tribute to one of Nature's pupils.

The Cathedral of Clermont is built of the dark lavas of Volvic. Nothing can exceed the beauty of the decorated work executed in this lava, the grey colour of which is very pleasing to the eye. The choir is very striking from its height, as it

rises "on pillars lofty and light and tall." Beautiful, too, are the long lancet windows in the apse and those of the clerestory, which are for the most part filled with rich stained glass.

Notre Dame du Port is a truly curious church, said to have been built about A.D. 580. It ranks among the historical monuments of France, and through the very early character of its Romanesque architecture and sculpture is of especial interest to the antiquarian. The elaborate decoration in mosaic of its towers is believed to be of the best Byzantine architecture, and the sculptures on the tympanum of the south doorway are curiously rude and unusual. The church is barrel-roofed, with an apsidal termination. The crypt, which is under the choir, is said to be the most ancient part of the building, and is remarkable for its rude pillars and massive roof. Here, as at Le Puy en Velay, is a black Virgin, probably the Roman Catholic adaptation of some Eastern idol. The petrifying spring of St. Alyre was once celebrated for the miracles performed there. There are many other springs in Auvergne possessing incrusting qualities, but none of them incrust objects exposed to their spray in so short a period as that of St. Alyre. Both Dr. Daubeney and Mr. Scrope attribute the immense quantity of travertine deposited by the water to the volcanic action below, and believe that the springs were fuller when the subterranean forces were in greater activity. Of the various objects placed on shelves and boards for incrustation by dripping are stuffed animals, their hair all coated with carbonate of lime, and stuffed birds; but the really beautiful specimens are crayfish and land shells, which preserve their shape entire in stone. There are also baskets, artichokes, and bird's-nests, with brooches made from casts and alto-relievos. Some of the latter are taken from coins found at Gergovia. The "Pont naturel" is worthy of a visit, forming as it does a natural arch which is constantly increasing.

When staying at Clermont some years ago we visited the late distinguished naturalist and geologist, M. Lecoq, to whom we had a letter of introduction from Sir C. Lyell. We found him most kind and communicative as to the points best worthy of observation. His museum was a model of good arrangement and careful keeping. Especially was it interesting to us in its illustrations of the natural history of Clermont Ferrand and its neighbourhood, of the rocks and minerals of the district, the fossils, the flora, the birds and their eggs, besides a large conchological collection from all parts of the world. M. Lecoq entered fully and unreservedly into his own views of the geology of the lacustrine beds of the Limagne, the extinct volcanos and their lavas. With regard to the occurrence of the glacial epoch and its effects in Auvergne, he considered that some

erratics had been transported by the action of melting snow, but he had then failed to find any signs of glacier action among the Auvergne mountains. M. Lecoq further directed our attention to the remains of the Marmot and Mammoth, teeth and bones of which animals he had obtained from crevices and cracks in the most modern lavas, such as those of Beaumont, Royat, and Volvic. We visited this museum again this summer, and saw completed that grand map of Auvergne which was coloured by this great naturalist with his own hands. Alas, that hand lies now cold in the tomb, and we missed sadly the courteous welcome and kindly explanations of many a relic rich and rare. His fine museum M. Lecoq left to his fellow-townsmen, a monument to his memory of an undying nature. The town museum contains a valuable collection of Roman amphoræ, utensils, and coins, some of which were found during the excavations made at Gergovia by the orders of Napoleon III. when writing his "Life of Cæsar." There is, too, a fair collection of stone implements, and the worst collection of daubs of oil paintings under the sun.

There is no greater mistake than to suppose that a walk to the Puy de Dôme, Pariou, and Graveneire will enable the geologist to comprehend the geology of Auvergne! Everyone should be possessed of the admirable work by Mr. Poulett Scrope on the "Extinct Volcanos of Central France;" yet even with this book at hand for reference it is not easy for those whose time is limited to select localities which will enable the tourist to grasp the striking geological phenomena presented by volcanic outbursts of long separated ages; of lacustrine formations of lakes now denuded 1,000 ft. in depth; of old river gravels far above the present river levels; and lava currents which once occupied valleys and gorges now standing out as mountain outliers, and cut clean away from the mass to which they originally belonged. I think that anyone who has, say, a fortnight at his disposal, would do well to devote his first attention to the granitic plateaux, through which the volcanos of the Puys de Dôme have been erupted, and those valleys and glens which had been eroded in the granitic rocks forming the old country before the outburst of the volcanos, and down some of whose valleys the more modern lavas have flowed for miles.

Granite Plateau.—A reference to the geological map of Central France shows a large tract of elevated country principally composed of granitic rocks set in a framework of strata of Jurassic age. It is evident also that granitic rocks constituted the *old land surface* through which burst the great miocene volcanos of Mont Dore and the Cantal, and that granite mountains formed the shores of the ancient eocene and miocene lakes. For the investigation of portions of the granitic plateau

near Clermont we recommend the walk through the village of Chamalières to Royat. The church of Royat is old and singular, and exhibits portions of early Romanesque architecture, and the village and valley are extremely picturesque. The lava which has been poured down from Graveneire into the valley is well displayed in a fine section near the "grotto," and a walk up the stream will afford a good idea of the excavations through the lava effected by the rivulet. Opposite Royat there is a quarry called the "Carrières Blanches," where a felstone porphyry is injected into the granitic rocks of Villar, and, protruding at the surface, forms a boss. Here we found growing, in May last, a large purple *Iris*, with *Anemone montana*; and many swallow-tail butterflies were chasing each other in the sunshine round the knoll. From thence we pursue the route to the hill of *Graveneire*. There is no crater; but immense masses of red and black scoriæ, lapilli, and pozzuolana, quarried for their materials, look as if they had been ejected yesterday, and tell the tale of igneous action as would a blacksmith's forge. The volcanic masses appear to have been erupted through fissures in the granite hill known as the *Puy de Charade*, and three streams of lava flowed down the slopes. Besides the Royat lava stream on the north, two streams flow towards the east and south. The eastern current was turned aside out of its course by the *Puy de Montaudoux*, a rock of basalt of far more ancient date, and which occupied its present position for untold ages before the volcanic outbursts of Graveneire had commenced. From Graveneire we recommend the walk to the Puy de Berzé.

The Puy de Berzé is more than 3,000 ft. above the sea, and its summit is capped by basalt overlying granite. We here remark the difference of position of this old lava as compared with that of the valley of Royat. Mr. Scrope thought that the basaltic currents which overflowed the freshwater beds of Gergovia, and the isolated Montrognon which forms so striking a feature in the scenery of Clermont, had their source in an aperture near the summit of Berzé, and flowed downwards into the lake, overflowing the lacustrine silts and their shells, where now stand Gergovia and Montrognon. Again, at St. Genest, there is a little valley with a rivulet into which has been poured a stream of columnar basalt with veins of quartz; and we see that the granitic mass had been here eroded before the outflow of the basalt. On the road to Montrognon and Clermont the granitic rocks are much disintegrated by the action of the atmosphere, and present appearances which might easily be set down as due to ice action. The rocks here and there by the roadside look as if they were *moutonnées* by ice; while the granitic masses separating at the joints form rounded boulders,

assuming precisely the aspect of *blocs perchés*. Another route across a granite country is to go by Chamalières over the Plateau de Prudelle by Sarsenat to Channat, and then to return by Nohanent and the Côtes de Clermont.

At Prudelle, at the height of 2,313 ft. above the sea, we find an ancient columnar basalt resting on granitic. The valley of Villar has been excavated in the granitic rocks since the overflow of this basalt, and down this valley has flowed the modern lava current from the Puy de Pariou. The geologist will not fail to remark the difference of position between the older and more modern lava currents. It is a good walk eastward across the granite country to the Puy de Channat, which is worth examining, as the recent volcanic masses have been blown right through a granite platform in advance of the line of the Puys de Dôme.

The Volcanic Outbursts of the Puys de Dôme.—Le Puy de Dôme is the great excursion from Clermont, and every geologist will ascend this noble mountain, which towers to the height of nearly 5,000 ft. above the sea, and is so striking an object from every point of view in the surrounding country. From its summit and observatory he will also gain some idea of the geography of the wonderful region around him, and mayhap from the grand panorama somewhat of its geology. There are volcanos all around, red with volcanic ashes, and craters yawning on their sides or peaks. There are hills rising high above the vales, which owe their protection to lava streams which flowed in ages so long ago that the volcanos which emitted them have been utterly swept away by denudation and degradation, or what was left has been obliterated by later volcanic outbursts. Then there are valleys which have been scooped out since the older basalts flowed, and these again bristle with lava torrents poured forth from the modern volcanos, which run in a line north and south from the Puys de Dôme. On the flank of the mountain itself blossom beautiful wild flowers. The noble yellow Gentian (*Gentiana lutea*) and the Martagon Lily (*Lilium Martagon*), with *Melittis grandiflora*, *Arnica montana*, *Ashantia major*, *Rhinanthus major*, and a score of other plants, were found by us in the sunny month of June, though snow still lingered on the heights of Mont Dore away to the southwards. Then there are rivers sparkling in the vale, and great hills looming in the distance, with hillsides clothed, some with forests, some with vines, and others bare and scorched as if by volcanic fires still slumbering beneath. Clouds gather over one distant range, and the sunshine lights up another, and you hear the thunder muttering from afar, while from below comes the tinkling of the sheep-bell, or a neighbouring church bell clangs through the still clear air. There is much to be seen from the Puy de Dôme.

Nevertheless, I cannot recommend the geologist to delay over its geology unless his time is of no importance. Mr. Scrope thought that the "Domite," or trachytic mass of which it consists, is of the same age as the volcanic products of the Puy de Pariou and Puy de Dôme. M. Lecoq assured us that he had arrived at other results, and was of opinion that the Domite belonged to the age of the trachytic lavas of Mont Dore, and that the newer Puys and their outbursts were erupted through and among the "Domite." If I may venture to pronounce an opinion, I should prefer the explanation of M. Lecoq. When we find a great extension of old basalts, apparently of the same age as the Mont Dore basalts, extending right away from Montredon on the south, by the Plateau of La Serre; again between Channat and Ternant; and as far northwards as Lague, south of the Puy de Jume, it is impossible to avoid the conviction that there was a great line of volcanic outbursts along the line of the Puys de Dôme of much earlier date than those late eruptions. But whether this supposition is right or not, none of the Puys just mentioned furnish such satisfactory displays of lava torrents and other phenomena as do the Puy de Pariou and many others. The Puy de Pariou is remarkable for its perfect crater, and is within a short walk of the Puy de Dôme. It is well to trace the lava current downwards to La Baraque, and observe the island of granite which it surrounds at Orcines and the check it meets with at the junction below Bonabry from the old basalt of Prudelle. When visiting Pariou in May (1876) we found the rim of the crater studded with the beautiful *Anemone montana*, with its maroon-coloured petals and bright yellow stamens. Below, near the outburst of the lava current, we gathered *Anemone ranunculoides*, *Corydalis solida*, *Scilla bifolia*, *Orchis sambucina*, *Pulmonaria officinalis*, *Daphne mezereum*, and a large variety of *Primula elatior*. Sir David Wedderburn made the depth of the crater by aneroid somewhat less than does Scrope, viz., 300 ft. A small *Viola* grew in abundance in the crater. From our notes, on a former visit in the month of July, I find that *Cephalanthera rubra* was found in the crevices of the Pariou lava current; this plant is extremely rare in England, having only been gathered on one locality of the Cotswold Hills in Gloucestershire, and in one copse in Somersetshire. Here, too, grows a peculiar rose with glaucous foliage and red stipules much dilated (*Rosa rubrifolia?*), and the guide asserted that it would not bear transportation. We gathered also *Lychnis viscosa*, a plant which grows too on Stanner Rocks, an ancient volcanic rock which traverses Silurian limestones near Kington in Herefordshire.

Another expedition among the more recent volcanic phe-

nomena may be made along the Pont Gibaud road as far as the Creux Morel, to examine the volcanic hollow near the Puy des Goules, and thence to strike westward for the Puy de Côme. This volcano rises more than 900 ft. above the plain. It has two craters, one 260 ft. in depth. The lavas which have flowed from it have spread over an area of 10 square miles, and its cinders cover the plain of the Creux Morel. The lava torrent may be traced from its source to the granitic peninsula east of Chambois, where it divides into two streams, one flowing over a vast platform towards Pont Gibaud, the other taking the direction of Mazayes. It is worth while to remain for a night at Pont Gibaud and examine the flow of the lava over sites where now are the village and castle; the meeting of the lava streams from Le Puy de Louchadière with that from the Puy de Côme; and the fine section of the valley of the Sioule river below Pont Gibaud. The Puy Rouge, near Chalucet, two miles from Pont Gibaud, has poured forth columnar basalt into the river, and there is a remarkable display of recent-looking scoriæ and volcanic bombs round the volcano itself.

Another excursion among the more recent volcanic rocks is to Volvic and the Puy de la Nugère. The rail takes us to Riom, and the walk from thence is full of interest. On the right are the picturesque ruins of the Castle of Turnuoel, and high above Volvic is a gigantic effigy of a Madonna, carved in Volvic lava, and 30 ft. high. The lava current of Volvic which flowed from the Puy de Nugère has been quarried since the days of the Romans, and is often studded with laminæ of specular iron. Tracing it upwards through a wood and narrow pass, we enter upon a broad valley, and see the lava encircling a low hill of granite; and following its course up to the volcano we find the Puy de Nugère, a cone with a deep oblong crater, and the lava pouring down the steep sides of the mountain. The geology of the Puy de la Bannière is quite different from that of Nugère. There is no crater; but masses of scoriæ and streams of lava have been erupted through a fissure in the granite plateau which stretches away for miles to the north, and overhangs the fresh-water beds of the lake of the Limagne, as it must have done when the waters rolled where now flourish the corn-field and the vineyard, and when the strange quadrupeds of miocene times frequented the granitic mountains and the shores of the great lake. On this hill, to the east of the figure of the Madonna, is a fissure, out of which has burst scoriæ, pozzuolana, and a thin lava stream, which seems to pass under the old Romanesque crypt of the church at Volvic. That rare British plant *Scleranthus perennis* was very abundant at this spot in the month of July.

One more expedition among the later volcanic hills and lava

currents we must not fail to recommend. This is to *Randanne*, and it may be taken *en route* to Mont Dore les Bains. Opposite the little hostel is a kind of summer-house, with very comfortable bedrooms, where quarters may be had for a night or two. This is a most extraordinary scene, when viewed from the summit of one of the volcanic Puys, and was selected by the Count de Montlosier as his home on his return to France in 1820, after many years of exile. His "Essai sur la Théorie des Volcans d'Auvergne" was published in 1789, and thirty years afterwards he returned to spend his last days among the mountains of the Puy de Dôme. He planted woods and cultivated the sterile soil, and when he died he was refused burial by the bishop of Clermont. This persecution was on account of his having written against the Jesuits in early life, urging them to use a cross of wood instead of one of gold, saying "c'est la croix de bois qui a sauvé le monde."

In May last we found the wood of Randanne, before entering the village, actually carpeted with spring flowers. There were violets, and primulas, and *Anemone montana* in thousands, *Anemone ranunculoides* and two or three orchids. The July list of Sir William Guise gives *Trifolium alpinum*, *Saxifraga stellaris*, *Sedum villosum*, *Geranium phæum*, and *Centaurea montana*.

The Puy de la Taupe rises close to the village, and a lava stream has flowed from its western flank. The view from thence right into the craters of the Puys to the north, backed by the distant Puy de Dôme towering above all, can best be characterized by the term weird. The Puys de la Rodde and de la Vache should be especially visited. Their craters, and the way in which their lava streams dam up rivulets and give rise to the lakes of Aidat and la Caissière must be seen to be comprehended.

The Older Basalts and Freshwater Beds of the Limagne.—We now revert to the older basalts, the products of much earlier volcanic eruptions than those we have just indicated, and masses of which are to be found capping many of the hills in Auvergne, sometimes more than 1,000 feet above the plains of the Limagne.

The Plateau de Prudelle is a mass of this ancient basalt, which overlies granite, and is within a short walk of Clermont. Two valleys, Villar and Gresinier, have been eroded on the south and north, down which have flowed recent lava streams from Pariou; but the old basalt of Prudelle has protected the granite promontory it overlies, and granite and basalt now stand out as grand witnesses of the gradual erosion of valleys, the resistance of hard lava, and the antiquity of the basalt. But the basaltic plateau, *par excellence*, for investigation, is that of

La Serre. The best way of reaching it is to drive or take a Mont Dore diligence to *Fontfredde*, a most interesting little valley, where a current of recent lava from the Puy Noir flowed, where now runs a stream, and rolled for ten miles down the valley of Théix to Julliat, near La Roche Blanche, and Le Crest. Crossing the stream at Fontfredde we walk over decomposing granite, and find ourselves on a great sheet of old basalt nearly two miles broad and ten in length, exhibiting all the characteristics of those wider basaltic platforms which we see in the Mont Dore country, in the Cantal, and in the Ardèche. The highest point, the Tête de la Serre, is nearly 3,500 ft. above the sea, and that accurate observer Mr. Scrope gives all the particulars of its characteristic features, the origin of its lava current in the granite, the flow of the lava down an inclined plane, the scoriæ on which the basalt rests, the denudation round the mass of granite on which stands the insulated basalt and castle of Montredon, and the proofs of four distinct steps in the process of excavation and denudation since the outflow of the lava of La Serre from the granite. Our advice is to trace this lava current from its source among scoriæ, masses of granite and volcanic bombs, to Chadrat, where it overflows freshwater beds of oolitic structure, and from thence to the picturesque village of Le Crest which alone is worth a visit.

Freshwater Beds and their Fossils.—Before visiting Auvergne I advise every lover of geology to give a day or two to the examination of the wonderful collection of the remains of fossil mammalia from the old freshwater beds of the Limagne, in the museums of the Jardin des Plantes in Paris. Nearly one hundred species of different quadrupeds have been found in the old lacustrine silts of Auvergne and Velay. Among them are great herbivora, such as mastodons, rhinoceros, tapirs, and deer, which ranged on the plains and pastured in the forests; and with these were great beavers, which lived in the rivers and lakes. There were beasts of prey allied to the tiger, hyæna, bear, and wild dog; and with these were associated large crocodiles and tortoises, snakes and frogs. Several extinct species of birds have been determined, allied to our swans, ducks, gulls, and swallows, and even the eggs of some of the water birds have been fossilized and preserved. These animals belong to miocene times, and should not be confounded with the eocene animals of Gannat, or the pliocene fauna of Mont Perrier near Issoire.

A fine section of the freshwater beds with their protecting cappings of ancient basalt is displayed in the well-known hill of Gergovia within a six-mile walk of Clermont. Gergovia is famous in history as the stronghold of the Arverni, who, under their brave chief Vercingetorix, defended it so gallantly against Julius Cæsar and his Roman legions. We visited Ger-

govia some years ago, soon after some excavations had been made, on the occasion of the visit of Napoleon III., when many Roman and Celtic relics were discovered. The best plan to attack Gergovia from Clermont is to drive by Beaumont and Aubières to the base of the hill. The superficial drifts of Beaumont have furnished the bones and teeth of mammoth and *Spermophilus*, a kind of marmot. The best sections of freshwater beds are on the northern and north-eastern flanks of Gergovia; and we recommend the searcher for fossils to walk up the stream from Romagnat by Clemensat, and then strike across for Gergovia. At the base of the series there occur the fossil snail shells (*Helix*) that are so abundant at the base of the Puy Dallet; and here M. Lecoq obtained freshwater mussels (*Unios*) while above rest the indusial limestones full of the cases of the larvæ of caddis flies, surrounded by minute freshwater shells. The eastern face of the camp is perhaps the best for seeing the position of two outflows of basalt and the deposition of lacustrine silts and fossil remains between the basaltic outflows. To the southward is a dyke through the freshwater beds, and this seems to be the site of a chimney by which volcanic materials were injected into and over the lacustrine silts.

On reaching the summit of Gergovia we arrive on a plateau about a mile and a half in length from west to east, by perhaps half a mile in width. It exhibits now no trace of the old Gaulish city, although the plough frequently turns up coins, and pieces of coarse pottery are often met with. The south face of the hill is evidently scarped, and the remains of a rude stone rampart of basaltic blocks may be traced. It would seem that the north face was sufficiently protected by the abrupt and precipitous character of its basaltic rocks. The platform is penetrated from north to south by five narrow rude roads, probably the ancient Viæ.

The prospect from Gergovia is truly grand and interesting, not merely on account of its extent, but from the variety of form, colour, and contrast due to the geological configuration of the country. On all sides rise isolated hills, some of them surmounted by fortresses, built in almost inaccessible places, by the feudal lords who were ever ready for warlike and violent deeds. These unruly barons were at last put down by Louis XIII. and Richelieu, and their strongholds destroyed. Such was Montrognon, which is close to the N.E.; and Montredon, which lies a little W. of the great basaltic platform of La Serre, of which it is an outlier.

The best descent from Gergovia is by the S.E. side of the camp, where a dyke of volcanic ash, scoriæ, and masses of lava have been ejected through a fissure in the freshwater beds, and through the lower basalts; and the protrusion of this dyke has

greatly disturbed and altered the beds at the point of contact. The freshwater beds may be seen tilted at a considerable angle, and when in contact with the lava have been altered into a hard compact limestone, with conchoidal fracture. At a considerable distance below the upper basalt of the platform a thick bed of consolidated volcanic ash is seen resting upon the freshwater limestone; it has put on the appearance of a lava bed, but the freshwater strata below it do not seem in the least altered.

We have not space to indicate half the interesting points to visit round Gergovia, but we may advise our brothers of the hammer to take an omelet at the little *auberge* at Merdogne, which is believed to be the locality noted by Cæsar in his account of the attack on Gergovia, according to the plan published in Napoleon III.'s "Vie de César." The hill above the village of La Roche Blanche is recognised as the "Collis sub ipsis radicibus Montis," which Cæsar seized by a night attack, and connected with his principal camp by a double foss; and Merdogne is fixed upon as the ground where Cæsar stationed himself with the 10th Legion, and from whence he caused the retreat to be sounded. I also would direct attention to the mass of subangular drift with large angular masses of rock contained in it, which occurs in a cutting of the road between Merdogne and the high road to Clermont. The northern shoulder of Montrognon looks as if volcanic masses had flowed down the slope *since the isolation* of that remarkable hill from that of Gergovia, with which it must once have been continuous. The geology of Montrognon is a good deal masked by the fallen ruins of the fortress and the weathering of the basalt.

Another expedition from Clermont for the older basalts is to go by rail or drive to Pont du Château for the Puy de Dallet. Driving, we pass on the right the Puy de la Poix, a local outburst of volcanic matter, into the lacustrine marls of the ancient lake. A great quantity of bitumen is associated with calcareous fragments, volcanic peperino, and vegetable matter. The Puy de Crouel and the hill of Clermont are both supposed to have the same origin as the Puy de la Poix, viz., the outburst of lava into the waters of the freshwater lake among masses of driftwood and other vegetable matter. At Pont du Château, on our visit in May last, a quarry opened at the end of the village before descending to the bridge over the Allier, exhibited a section of what was evidently a volcanic vent into the freshwater beds, showing that at this point also volcanic eruptions were going on during the formation of the lacustrine silts at the bottom of the lake. When here some years ago, in the month of July, we were walking up the right bank of

the Allier to Scrope's celebrated river section, when we were struck by what appeared to be, at a short distance, some large bright blue flowers. On approaching them they proved to be dwarf elder bushes (*Sambucus niger*) covered with a quantity of small azure chafers (a species of *Hoplia*), a beautiful insect much used in Paris and other towns for brooches, necklaces, &c. So numerous were these blue chafers that the panicles of the elder-flowers were studded with them, and presented a remarkable spectacle.

Scrope's section of the cliff on the banks of the Allier at the base of the Puy de Dallet is well known, and the principal point to direct attention to is the lowest bed, exhibited when the river is low—which it was not at our last visit. It is a limestone, charged with volcanic fragments as if there had been a volcano on the borders of the lake, which erupted an abundance of scoriæ. Over this lies a limestone full of the casts and remains of land and freshwater shells, some of them snail shells (*Helicidæ*) washed into the lake; others freshwater shells, such as *Planorbis* and *Lymnœa*, which lived in the waters. It is probable that these beds on the Allier represent those at the base of Gergovia, where also *Unios* are found. The highest bed of the section is full of volcanic matter. The beds dip westward, and behind the cliff we see the isolated mass of the Puy de Dallet, composed of strata similar to those of Gergovia, though so masked by vineyards and cultivation that it is difficult to make out their succession. The basaltic platform, too, is much broken up at the surface by atmospheric action and decay. The observer will see the cliff near the road to the village of Dallet, capped with a river drift of an ancient Allier, which flowed far above the present river level. Again, he will not fail to remark a road section before descending the hill to Dallet, where a thick mass of atmospheric drift overlies the old river-bed, and that this must have accumulated under different circumstances to the present.

The Mont Dore.—The road from Clermont to Mont Dore passes by Montrognon and the *moutonnée*-looking granitic rocks to Fontfredde and Randanne, which is the place for the traveller to make inquiries about ponies or horses when at Mont Dore les Bains. So late was the spring of 1876, that between Randanne and the Rochers Sanadoire and Tuilière we passed pine woods with numerous branches lately broken off by the weight of May snows, and hardly a plant showed its blossoms along the great tract of ancient lava currents over which the road passes. We passed some time in the examination of those well-known rocks—the Rochers Sanadoire and Tuilière —and there are none more grand and picturesque in the Mont Dore country. They rise like giant pyramids on the opposite

sides of a lovely wooded glen—sentinels to the approach to the old volcano. They consist of columnar phonolite, and it is impossible to describe the beauty of the shaft-like columns of Tuilière. Some of the columns are curved, and slates are quarried at Tuilière in cleavage planes, which are at right angles to the axis of the columns. We remarked, too, the inter-bedding of yellowish, soft, trachytic ash, with beds of hard basalt on Puy Gros. This soft trachyte weathers out easily, and its consequent denudation is the cause of the beautiful valley scenery we drive along *en route* to Mont Dore les Bains. Lake Guery, which is passed on the right, is famous for its red-fleshed trout, and the lake itself is walled in by basalt from the Puy Gros. It is from the Puy de l'Aiguiller, on the north, that the great lava current has issued which stretches for a distance of fifteen or sixteen miles along the banks of the Sioule river, and covers the granitic plateau at Pont Gibaud. Those who visit Pont Gibaud from Clermont may thus gain some idea of the extension of the ancient lava currents of Mont Dore.

It is impossible to give a better description of Mont Dore than that of Scrope, viz., a great volcanic mountain like Etna or Teneriffe, which has been reduced to a mere skeleton by the wear and tear of long ages of denudation; and no geologist can cross its peaks and cols, traverse its lava currents, explore its valleys all round the base, as we have done, without seeing how the upper and softer materials of the volcano have been swept away to form conglomerates and breccias, which have been carried for miles, and the very innermost dykes and porphyritic masses of the inner structure have been laid bare.

With regard to the volcanic structure of Mont Dore the phenomena are far too vast and varied to be treated of here; but we may say that a steady examination of the valley of the Dordogne on one side, and the valley of Chambon on the other, will go far towards giving the physical geologist a good idea of its history. Scrope's section of the Cascade du Mont Dore, with its succession of soft trachytes, interlaced with hard lavas and basalts, is a good lesson in volcanic structure; while the study of the valley of the Dordogne from side to side, and the evidence that it has once been filled with volcanic materials to the level of the upper basalt, and has since been eroded to the depth of 800 ft., is a lesson on the denudation and erosion of the other valleys.

We visited Mont Dore in May, 1876, for the purpose of examining into the evidence of glacial action, and the former existence of ancient glaciers in Central France, suggested by Dr. Hooker, of Kew, in a contribution to "Nature," of Nov. 11, 1875. The glacial appearances due to weathering among the

granitic rocks of the Monts Dôme had made us all, perhaps, over careful, and we were none of us the least inclined to make lateral moraines of mere local *débris* or *roches moutonnées* of weathered granite.

The valley of the Dordogne was yellow with the flowers of *Primula elatior*, and the bright blue blossoms of *Gentiana verna* were glistening on the slopes of the Cascade side by side with *Thlaspi alpestre* and purple pansies (*Viola tricolor*); but the heights of Puy Ferrand and the Pic de Sancy were white with snow, from which a thousand streamlets poured, laden with detritus, and affording an excellent illustration of the power of melting snow in carrying detritus from mountain slopes to a lower level. In fact, the valley of the Dordogne is now every spring-time everywhere percolated through and through by running water, and if there was a glacier there, in days long ago, the numerous streamlets produced by the melting snows and rains must have long ago sorted the glacial *débris* and rolled and washed the materials.

The masses of rock known as "Les Trois Diables" appear to be fallen masses, and the bristling pinnacles of the Gorge d'Enfer called "Les Cheminées du Diable" are about soon to follow their example and hurtle downwards into the abyss below. The wind was bitterly cold at the Gorge d'Enfer, and the snow lay deep in its gullies. Here and there the rosy blossoms of *Androsace carnea* looked like blood-spots among the snow, on which we picked up a dead Brambling finch (*Fringilla montifringilla*), which had succumbed to the cold. Passing over a *coulée* of snow, I ascended to the basaltic platform above, and there saw masses of trachyte and felstone resting on basalt, which could hardly be fallen *débris*, and I was thus led to believe that a glacier had passed over the higher platforms of basalt *before the erosion of the valley.* I also called the attention of my companions to what I think is moraine matter, and transported rock masses of trachyte resting on basalt, on the road between Mont Dore les Bains and La Cour, as on the basaltic platform below the Rochers de Beauzac.

Above the entrance of the valley of La Cour we cross the Dordogne and wind up the zigzag towards the Pic de Sancy. Opposite to the "Vallée de la Cour" is a deep gorge, dividing the Cacadogne and the Roc du Cuzau, and from this gorge rises the "Roc Barbu," a mass of columnar basalt which is interesting, as it was believed by Scrope to occupy nearly the site of the great crater of the ancient miocene volcano. No one can examine into these inner recesses, and afterwards explore the volcano round its base, and observe the enormous masses of volcanic materials spread forth from a common centre, without becoming convinced, first, that the formation of the volcano

must have occupied a long period of volcanic activity; and secondly, that the destruction of its original shape must have been caused by long ages of quiescence. Had the volcano continued in action, the effects of erosion would soon have been obliterated; while the deep valleys and gorges tell of long continued denudation since the last outbursts from the Mont Dore crater.

Our route to the Tranteine valley passed over the Col between the Pic de Sancy and Puy Ferrand, and our guide was Guillaume Pierre, of the Hotel Chabory ainée, whom we can recommend, and to whom I pointed out various phenomena in the Tranteine gorge which I commend to others who have time at their disposal for examination.

The head of the Mont Dore valley is a semicircle of precipitous mountains, buttressed with jagged dykes of hard trachyte and columnar basalt, and intrusive masses of felstone porphyry. Looking northwards we behold the deep valley and amphitheatre of the Dordogne, and huge pinnacles of rock which shoot up from the lateral Gorge d'Enfer. Far and wide the eye beholds volcanic hills, many so bare of vegetation as to give the distant view an aspect of sterility. At one point you see the modern volcanos of the Monts Dome; at another you look upon the older volcano of the Cantal, glistening with snow as if to assert its more hoary longevity as a patriarch of other days. The gorge of Chaudefour opens out to the north-west, below Puy Ferrand, and we look down on bristling rocks, sheets of basalt, the valley of Chambon, the old castle of Murol, and the modern volcano of the Puy de Tartaret, with the lake of Chambon dammed up by its lava current. The Tranteine valley runs due south, and faces the country of the Cantal. High above its northern gorge rises the Pic de Sancy surmounted by a cross. The Pic itself owes its shape and preservation to the slow weathering of a hard felstone porphyry, which Mr. Scrope calls a "porphyritic trachyte," and which is important to bear in mind as a good local rock to mark for evidence as respects transportation, like the granite erratics of Mont Blanc.

The transported rock masses sketched by Dr. Hooker in "Nature" are distant a mile and a-half from the summit of the Pic de Sancy, and I took the guide from the Col at the head of the pass down the gorge. Nearly in the centre of the gorge we came upon a *roche moutonnée*, close by which flows a rivulet; and on both sides the hills, as they slope downwards towards the south, are studded with perched blocks resting on masses, *in situ*, of different mineral composition, and of which the only way of accounting for the distribution, save that of a glacier, is that they may have been shot out of the volcano and,

fallen where they lie. The transported blocks described by Dr. Hooker are stranded against a low sloping hill at the mouth of the gorge. This low hill consists, as shown by sections in the streamlets, of basalt and moraine matter. In the moraine matter, Dr. Hooker found scratched and polished stones. No one can examine the section below the waterfall of the Tranteine stream without seeing that the great blocks are masses transported from the upper part of the gorge, resting in moraine matter, and on sheets of basalt. The larger masses consist of felstone porphyry from the Pic de Sancy, but there are others of trachyte and basaltic lava which show signs of great weathering. On the right and left of the transported rocks the hills are weathered and rounded, and have *blocs perchés* resting on them. Here, as far as I read the history, rest the relics of the last of the glaciers among the valleys of Mont Dore, stranded against the low hill which a glacier of larger size once swept over and stretched far down the valley towards Latour and Picherande. But why should glacier relics be preserved so well in the Tranteine valley and obliterated in that of the Dordogne? It is accounted for, in my opinion, by the great difference in the watershed of streamlets and the freedom, comparatively, from the constant wear and tear of tributary rills of water rushing through the glacier débris. The Tranteine stream does not shift its bed as does the Dordogne, and the moraine matter and transported rocks, resting on the hill in question, are comparatively free from the wear and tear of running waters. For some reason or other it was also evident from the backward vegetation that the Tranteine valley is colder than that of the Dordogne. Professor Lasaulx, of Breslau, in a paper written in the "Ausland" of 1867, directs attention to glacial phenomena near the village of Latour, and I regret that I did not receive the "Ausland" until after our return from Auvergne, for we also went to the Tranteine valley by the long, roundabout route through the village of Latour. On reaching the basaltic platform on the road to Latour, and before reaching the pine woods, I thought it was impossible to account for the presence of some transported masses of trachytic lava which rest on basalt without the aid of ice. We pass by the remarkable basaltic rock known as the Rocher de Vendeix, and come upon a granite district and its deceitful weathering. At Latour are vertical faces of columnar basalt, dykes of which burst through the granite and strew the slopes with their débris. Between Latour and Bousquet M. Lasaulx describes "basaltic prisms polished on the surface by glacial action;" and "erratics resting on rounded and polished granite."

The high road from Latour to Besse crosses the Tranteine valley about 1½ mile from the village of Picherande, and the distance

from thence to the transported blocks is about 5 miles, over an uninteresting route, which is not to be compared for scenery and geological phenomena to that over the Col by the Pic de Sancy. It has, however, the advantage of being much easier in transit. The valley here is a gradual ascent for nearly 5 miles over a poor peaty pasturage with low eminences of granite, overlain by basalt. The country has a *moutonnée* appearance as if a glacier had come over it a long time ago; and on the slope facing some burons above the road-bridge I detected a boulder of felstone porphyry from the Pic de Sancy. Arrived at the rock masses already described, Sir David Wedderburn made the height of the ridge against which they rest 4,500 ft. above the sea, or 1,509 ft. below the Pic. Mr. Lucy also made full notes on the position of the felstone porphyry and the surrounding geological phenomena. We advise a walk back along the stream to the village of Picherande, as it shows great stranded rock masses on both sides of the stream, especially below the little waterfall near where the erratics are situated. The road to Besse traverses a desolate country, and so backward was the season that, although the 20th May, there was not a leaf on the trees, and the only plant seen was *Petasites albus*. This southern flank of Mont Dore is far colder than the northern side. We passed Vassivière, situated on the bleak hill-side, and where annually a great religious fête is held in honour of Notre Dame de Vassivière, and examined the crater lake, Lac Pavin, which is a most striking scene with its crater-walls clothed with wood and its weird-looking hollow filled with waters dark as Erebus. Besse still retains many of the features of an old mediæval town. Many of the houses are built of stone, and display in the soffits of doors and windows much architectural enrichment of the thirteenth or fourteenth centuries. One house was pointed out as the "Maison de la Reine Marguerite," who, we were told, "mangeait des petits enfans." It bears traces of having been a building of some importance, as there is a broad winding stone staircase in a tower which terminated in a stone vault, on bosses of which are carved figures with the letter (M), possibly the initial of Marguerite. Relics of the old town walls still exist, and on an angle of wall is a stone with the following inscription:—

I. BARBVT
I. BESSEIRE
CONSVLS
1010.

We were quartered at the hostelry of "Le Cheval Blanc," and supped off a trout 5 lbs. in weight, from Lac Pavin. The road between Besse and Murol is rough and hilly, but the turf was in some places enamelled with the purple blossoms of *Viola*

tricolor, the parent, probably, of our garden pansies. The little village of Murol is situated on the modern lava current which has flowed from the Puy de Tartaret, while the ruins of the grand feudal castle tower above on the old basalts from Mont Dore. This castle is a most noble and imposing structure still. Its position is grand when viewed from below, while its great mass, its towered outworks, and massive central tower, impress the mind with a sense of solidity and power. It was ransacked and ruined in the revolution of 1793. The views on all sides are very extensive, and most remarkable altogether is this feudal fortress of Murol. The Lake of Chambon is up the valley about a mile, and owes its existence to a dam of lava from the Puy de Tartaret, an extinct volcano with two craters and a cone made up of volcanic cinders. Most astonishing, too, are the accumulations and breccias of the Dent du Marais. Everywhere in this country we are struck with geological phenomena on the grandest scale. First we remark the flow of the old lavas, which form great basaltic platforms high above the present valleys; and yet these basalts and their accompanying breccias must once have flowed in valleys which existed before the erosion of the present watercourses. Again, the recent lava of Tartaret flowed down the existing valley of Chambon when it was excavated as it is now, and this lava has been excavated by the river to great depth. Thirdly, it is quite evident that no glacier has passed down the lower part of the valley since the eruption of the cinder cones of Tartaret and d'Eraignes. Have we any date, then, of the eruption of these cinder cones, for this will assist us in the glacier history? We have. It is recorded by Sir C. Lyell ("Student's Elements," 2nd ed. p. 528), that the lava of Tartaret flowed over the alluvium of an old valley which contains the remains of the Siberian hare (Lagomys), and the fossil horse; and that the arches of a Roman bridge spring from the lava of Tartaret, showing that the ravine near St. Nectaire was in Roman times excavated much as it is now. Remains, too, of the mammoth have, we understand, been found in drifts of the river Couze. So it seems that the northern animals, the mammoth and lagomys, have lived in France since the *outbursts of Tartaret*. Our space will not permit of further allusion to St. Nectaire than to direct attention to its fine old Romanesque church, with an apsidal choir and barbaric representations of men and animals in colour, its cromlech on a hill-side between the upper and lower baths, and the beautiful drive by Champeix to Issoire. The road passes through a picturesque gorge on the river Couze. And here we strike the old granite basement rock through which burst the ancient volcanic masses of the Mont Dore volcano. The lava from Tartaret flows down the valley eroded by an ancient Couze,

and follows the windings of the old river, whose gravels may be seen along its course. Here and there this lava is columnar, and the granite itself appears to be in places traversed by dykes of basalt. The situation of the old town of Champeix is very picturesque, on a commanding eminence at the mouth of the gorge, which is crowned with the massive remains of an old castle. At Nechers the lava from Tartaret stops, having flowed fourteen miles down the river channel. Near Nechers the river has cut through a fine section of the freshwater beds over which the Tartaret lava has flowed in the gorge. Before entering Issoire we arrive at the Montagne de Perrier, with its rock dwellings "Les Grottes de Perrier," which are referred to Roman times. The Mont Perrier tuffs and conglomerates are famous for their rich bone breccias, containing the remains of a great number of animals which appear to have lived in this country in pliocene times. It is difficult to account for these conglomerates, and those of Champeix and Nechers, save that they were carried to their present site by a river which flowed in the same direction as the Couze. From the Mont Perrier conglomerates have been extracted the remains of bears, tigers, hyænas and otters, beavers and hares, associated with mastodons, rhinoceroses, stags, and tapirs, and they lie in gravels and drifts which are interstratified in beds of tuff conglomerate which were laid down at a period long after the miocene volcano of Mont Dore had burst into activity, when the tuffs and lavas it erupted had been borne for miles down valleys, when the old miocene lakes had been turned into dry land, and deep valleys eroded in their silts. Verily this is an astounding country, this Auvergne. It will take years yet to comprehend its geology. Much as has been done by Scrope, Lecoq, and others, there is still far more to do before its dry bones are sorted, its different volcanic outbursts defined, and the strange history they have to tell is revealed. No one has, as yet, an idea of the wonderful physical changes which have occurred during eocene, miocene, pliocene, and post-pliocene ages, which we doubt not will be more or less realised by future geologists. No one has as yet separated the Gannat beds and those of Le Puy en Velay, with their eocene fauna, from the miocene strata crowded with the relics of miocene animals. No one knows under what condition the pliocene animals lived when the Mont Perrier tuffs were accumulating; or what the conditions were when the mammoth and long-haired rhinoceros and marmot lived on the Monts Dome. Still there is some light shed upon all these histories, and if after three visits to the volcanic regions of Central France I may be permitted to give a broad opinion as to the glacial history of Auvergne, I should say that it was long, long ago. When the Alpine glaciers

reached the Jura, and the Rhine glacier swept over the plains of Bavaria, when there were glaciers in the Vosges and in the Black Forest; then I believe glaciers swept across the upper basaltic platforms which are now high above the valleys of Mont Dore. When the great Alpine glaciers passed away, so melted also the glaciers of Mont Dore, and the mammoth and hairy rhinoceros pastured in the vales, with lagomys and spermophilus on the mountains. There may have been short glaciers among the hills, extending only a little way down the valleys, as the transported rocks of Tranteine seem to testify. But the relics of such retiring glaciers are difficult to recognise; and so masked is the evidence of glacial action by the wear and tear of long ages of atmospheric actions, the wash of many streams, and possibly by later volcanic outbursts, that I am convinced much yet remains to be explored before we shall read aright the history of the Glaciers of Auvergne.

EXPLANATION OF PLATE I.

Sketch-map of the volcanic district of the Auvergne.

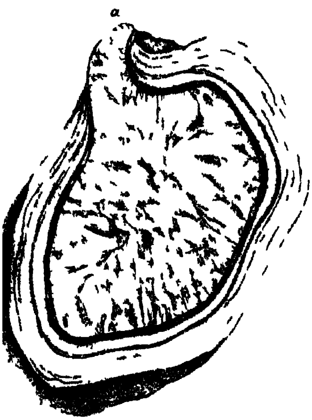


Fig 1

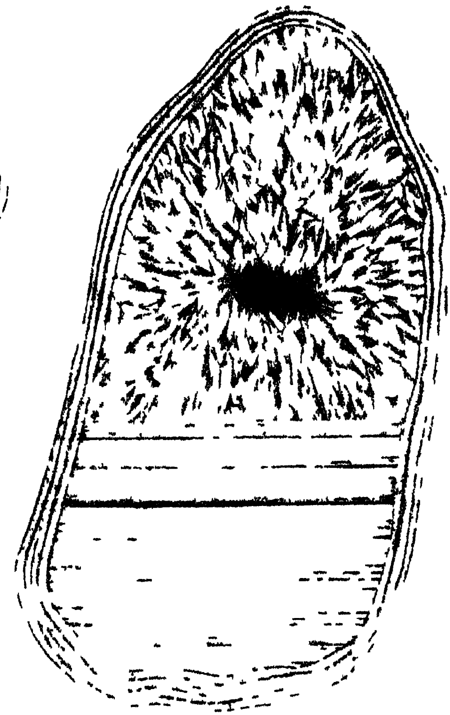


Fig 2

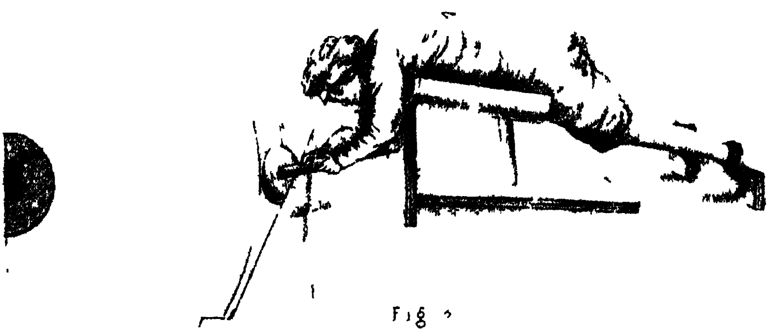


Fig 3

AGATES AND AGATE-WORKING.

By F. W. RUDLER, F.G.S.

[PLATE II.]

MOST of our fashionable watering-places offer to the visitor an attractive display of agates and other siliceous stones, worked into a vast variety of ornamental forms. From the abundance of these agates it might fairly be assumed that the rough stones are to be had upon the neighbouring beach for the mere trouble of gathering them. It is true, there are many spots along our coasts where the diligent seeker occasionally finds a pebble which, dull as it may seem on the outside, needs but the touch of the lapidary's wheel to bring to light its

"Chalcedonic beauties, fair and bright."

Such pebbles, however, are as a rule by no means common, even in localities of repute; and it may be safely said that on no part of the English coast could agates be found sufficiently large for the manufacture of paper-knives, bowls, vases, and many other objects commonly exposed for sale. Moreover, these objects are generally offered at so extremely moderate a price that, wherever the raw material may be found, it is clear that it must be cut and polished in some locality where labour is much cheaper than in England. Usually, however, the inquirer considers such difficulties solved when he learns that the stones in question are German agates. Yet this explanation, as we shall presently find, is far from satisfactory. Indeed, we believe that, as a matter of fact, no agates worth naming have for many years been obtained from German soil; and although the old agate-mills are still active they have long been working exclusively on imported stones. We have, therefore, no more right to call such stones "German agates" than we should have to speak of a piece of Carrara marble as "English marble" simply because it happened that it had been worked into form by the chisel of an English sculptor. The true history of these agates, the localities whence they are

obtained, their probable mode of formation, and the methods of cutting and polishing—are the subjects which it will be our business to explain in the present article.

As the tourist ascends the Rhine, and is about to leave one of the most picturesque parts of the river for the broad valley of the Rheingau, he passes, opposite to the vine-clad hill of the Niederwald, the mouth of the River Nahe. This river opens into the Rhine on its left bank, just below Bingen, and a little above the well-known Mouse Tower. The visitor will find the valley of the Nahe almost as beautiful as that of the Moselle, to which it runs nearly parallel, the two valleys being separated by the Devonian rocks of the Hundsrück Hills. Some distance after passing Kreuznach, with its baths, and the neighbouring salt-works, the explorer, following the windings of the river, reaches the picturesquely seated town of Oberstein, about forty miles from Bingen. It is this little town which has been, time out of mind, the great centre of the agate trade of the world. Although situated in the southern part of Rhenish Prussia, Oberstein and the rest of Birkenfeld form an isolated patch belonging to the Grand Duchy of Oldenburg—a kind of political outlier of the far-distant Duchy, entirely distinct from the surrounding Rhine Province.

Few branches of industry owe their birth more directly to the geological structure of the district in which they are seated than the agate-industry of Oberstein. Those hills which rise behind the town in grotesque crags, crowned by the relics of baronial castles, consist of an eruptive rock which German geologists are in the habit of calling melaphyre. It is this rock too which is penetrated by the railway in the neighbourhood of Oberstein, and has thus given rise to the cuttings and tunnels which the visitor passes through, whether he approach the town on the one side from Bingen, along the foot of the Hundsrück, or on the other side from Trèves through the rich coal-field of Saarbrücken. The melaphyre has burst through the sandstones of this coal-field, and comes to the surface in several masses, the largest of which occupies a considerable area around Oberstein, where it is surrounded on all sides by Permian rocks, and is cut through by the river Nahe and its tributary streams.

It would be difficult to find a word in the geologist's vocabulary which has been more abused than Brongniart's name "melaphyre," save perhaps our conveniently ambiguous term "greenstone." A good deal of uncertainty hangs over the original definition, but this has been vastly increased by the different ways in which the term has since been applied. A plagioclastic felspar is the prime constituent; and, according to M. Delesse's analysis, the felspar of the Oberstein melaphyre

appears to be labradorite.* Specimens from the railway-station contain a plagioclase of blood-red colour, due to the presence of lamellæ of ferric oxide.† Microscopic research has shown that in many melaphyres the plagioclase is associated with an orthoclase. Formerly it was supposed that the rock was destitute of olivine, and in this respect differed markedly from basalt; it has, however, been found of late years that olivine is frequently present, and indeed it is difficult to separate some melaphyres, when fresh and unweathered, from true felspar-basalts. Augite, however, is not so constant a constituent of melaphyre as was formerly supposed; in some cases the augite appears to be transformed into a chloritic mineral, and indeed much of the Oberstein rock has a greenish tint. Magnetite is always present, as in so many other eruptive rocks.

Some varieties of melaphyre are compact in texture, others porphyritic, and others again amygdaloidal. All these varieties are to be collected in the neighbourhood of Oberstein, but it is only the last named that is of interest for our present purpose. Just as the carbonic anhydride disengaged during fermentation imparts a cellular character to the dough, which is retained in the bread; so, while the palæozoic lava, which we call melaphyre, was still plastic, bubbles of gas or of steam were disengaged, and have left their impress in the rock, the molten matter having been sufficiently tough to prevent collapse of the walls. Although the normal form of these bubbles would be more or less globular, or probably pear-shaped, with the narrow end downwards, it has generally happened that, during the flow of the lava, the cavities have been drawn out in the direction of the current, so as to form elongated rather flattened cavities, resembling an almond in shape, whence the common name *Amygdaloid* or *Mandelstein*. These vesicles are in some cases empty; but usually they are filled to a greater or less extent with mineral matter, which has been deposited in them by chemical changes occurring in the rock subsequent to its formation. In many amygdaloidal rocks the mineral is merely carbonate of calcium, as may frequently be seen in our well-known Derbyshire "toadstones," which are melaphyres interbedded in the Carboniferous Limestone. But the cavities in the amygdaloidal rocks of Oberstein are for the most part filled with silica in some of its Protean forms. As you pass along cuttings by the road-side you may see the rock charged in some places with myriads of little chalcedonic nodules, or rudimentary agates, which look like so many fossil almonds. Indeed,

* Delesse: "Sur le Porphyre Amygdaloide d'Oberstein" ("Ann. des Mines," [4], xvi. p. 511.)

† Zirkel: "Die mikr. Beschaff. d. Min. u. Gesteine," p. 414.

the notion that the agates of Mount Carmel were petrified melons, was seriously entertained by a writer of only a century and a half ago.* Frequently the siliceous nodules are so abundant that the rock does not look unlike a conglomerate, and some mineralogists have even supposed that the agates are really pebbles and the enclosing rock nothing but the cementing material.†

Although it is almost universally admitted that the vesicular cavities now occupied by the agates have originated in the manner described above, it is only fair to remark that a few Neptunists, unwilling to attribute an igneous origin to basalt and melaphyre, have sought to explain the formation of the cavities by assuming that they represent crystals in a porphyritic rock, which have been removed in solution, thus leaving angular hollows, the walls of which have since been rounded and otherwise modified by various solvents which have gained access to the cavities.‡

To explain the formation of an agate, with its concentric layers of chalcedony, jasper, quartz, and other siliceous minerals, is by no means so easy a matter as may at first sight appear. Not that there is any difficulty in getting the needful supply of silica to form the agate. It may be fairly assumed that some of the component minerals of the agate-bearing rocks will suffer decomposition by meteoric waters holding carbonic acid gas in solution, and that among the products of decomposition free silica will be found. It is notable that the more altered the rock, the finer the agates it contains; thus suggesting some relation between the destruction of the rock and the construction of the agates. We have seen that labradorite is a constant constituent of melaphyre; and this is, of all felspars, the most prone to alteration. Acted on by carbonated waters the silicate of calcium is decomposed, and a carbonate formed, whilst silica is set free. It should be remembered that the siliceous minerals in an agate are often accompanied by carbonate of calcium and by various zeolitic minerals. A large crystal of calcite may frequently be seen seated in the drusy interior of an agate-geode; and it has even been suggested that the so-called "fortification agate" may owe its angularity of outline, as seen in section, to the deposition of silica, either upon or in the place of pre-existing crystals of calcite or of some zeolite.§

* Breye: "Epistola de Melonibus petrefactis Montis Carmel." 1722.

† Volger: "Studien zur Entwickelungsgeschichte der Mineralien," p. 533.

‡ See Bischof: "Lehrbuch d. Chem. u. Phys. Geol." 1866, Bd. iii. p. 620.

§ "On Quartz, Chalcedony, Agate, Flint, Chert, Jasper, and other Forms

But though there may not be much difficulty is tracing the origin of the silica, there are on the contrary extreme difficulties in seeking to interpret some of the appearances presented by agates. Why, for example, should the silica, in one and the same stone, be sometimes deposited in the form of chalcedony, and sometimes shot forth as crystallized quartz; now deeply coloured as bright red jasper, and now delicately tinted as purple amethyst; at one time affecting a crystalline condition, and at another time colloidal? Such alternations in the character of the deposits must have recurred again and again in the history of many banded agates. The successive strata differ considerably in texture, hardness, transparency, colour, and other physical properties; but what has determined these differences? Layer after layer has been spread in equal thickness over all the irregularities of surface, each coat exquisitely thin and delicate; Sir D. Brewster measured the thickness of some of these strata, and found them between $\frac{1}{17220}$ and $\frac{1}{55760}$ of an inch.* How have layers of such extreme tenuity, and yet continuous, been deposited all round the inner walls of an irregularly shaped cavity? These are questions which, simple as they may seem to some at the first blush, will be found to grow in difficulty the more carefully they are studied.

Jakob Nöggerath, the venerable professor at Bonn, who many years ago paid great attention to the study of agates, always maintained that the liquid from which the silica was deposited gained access to the cavities through special openings, or inlets of infiltration.† In some specimens the canal actually remains open, but usually it has become choked by continued deposition of silica. An agate may be so cut by accident that the section passes through this infiltration-channel, as in fig. 1, Pl. II., where the original inlet is seen at *a*. In some specimens several openings of this kind may be detected. Assuming, however, that the solution of silica was thus introduced, it is difficult to see how the deposit could have been regularly thrown down in concentric layers all round the walls of the hollow; no thicker, be it remarked, on the floor of the cavity, than on its roof. It is true we find in certain agates horizontal layers, as though the mineral matter had settled on the floor in obedience to gravity; but then we are perplexed at finding that these flat bands often alternate in the same specimen with regularly concentric deposits, which run with uniform thickness all round the

of Silica geologically considered." By Professor T. Rupert Jones, F.R.S., &c. "Proc. Geol. Assoc." vol. iv., p. 443.

* "Philosophical Magazine," (3), vol. xxii. p. 213.

† Ueber die Achat-Mandeln in den Melaphyren. Haidinger's "Naturwiss. Abhandlungen," vol. iii. part i. pp. 93, 147.

walls, as shown in fig. 2, Pl. II. Bischof suggested that the horizontal bands were formed when the fluid, having been introduced rapidly, was then allowed to rest in the bottom of the cavity; whilst the concentric zones were precipitated from a solution which filtered in slowly, and merely spread over the walls without accumulating on the floor.* To avoid the difficulty of explaining the formation of banded agates by admission of the liquid through special inlets, another hypothesis was advanced by the late Professor Haidinger. According to him the genesis of an agate could be best understood by assuming that, instead of a local infiltration, there had been a general exsudation through the walls of the cavity, so that all parts—the roof not less than the floor—would thus become uniformly coated with silica. The great objection to this explanation lies in the difficulty of understanding how the solution could continue to gain access to the cavity after the first impermeable layer had been deposited. Most mineral substances are porous, and Bischof has cited the case of a compact basalt which when freshly broken was found to contain drops of water in the very heart of the rock. Some of the layers of agate are permeable with great ease, either through distinct pores or between the fibres of which chalcedony commonly consists, as shown under the miscroscope. But it will be presently seen, when referring to the method of staining agates, that whilst some layers are thus freely permeable others appear to be absolutely impervious; and it is difficult to conceive how the agate-forming process could be continued after an impervious lining had once been thrown down upon the walls. To meet this objection, however, it is argued that every agate is sufficiently penetrated by direct fissures to offer means of ingress to the siliceous solution. Whatever views may be held as to the formation of the main mass of the agate, it is generally believed that the first lining of the cavity, in the form of a thin layer of delessite, or ferruginous chlorite, which constitutes the green rind of most agates, is the result of a general percolation and not of local deposition.

As both theories obviously present difficulties, a third mode of origin has been suggested by Dr. Reusch.† If a thin cream of plaster of Paris be introduced into an irregularly-shaped cavity, shaken round, and then poured out, a layer will be left lining the walls of the hollow; by introducing in this way plaster of various colours, successive layers are formed; and, on cutting open the nodule, the appearance presented is strikingly similar to that of a section of a banded agate. Reusch supposes

* "Lehrbuch d. Chem. u. Phys. Geologie," 1866, vol. iii. p. 630.

† Ueber den Agat. Poggendorff's "Annalen," vol. cxxiii. p. 94.

that by the action of intermittent thermal springs the cavities in the amygdaloidal rock have been alternately filled and emptied. The solution carried upwards would certainly be more concentrated, and probably more highly coloured than the descending solution, from which much of the silica had of course been separated during its sojourn in the cavity; hence the differences in the characters of the different layers. Not altogether satisfied with this theory, Herr Lange, of Idar, has suggested some modifications which he conceives will help to account for the regular deposition of thin layers lining the walls of the cavity.* He supposes that after gelatinous silica has been precipitated on the floor of a cavity, an accession of temperature causes the water to boil, and the pressure of the steam then forces the jelly in all directions against the walls of the enclosed space. If the tension of the steam become too great, it forces an exit by piercing the shell; hence what we commonly call inlets of infiltration may after all be exactly the reverse—eruptive, instead of irruptive, canals; channels of egress rather than of ingress.

Both Reusch and Lange argue in favour of the deposition of silica from heated solutions. Great, without doubt, is the solvent action of water at a high temperature, and great the proportion of silica capable of being thus held in solution, as testified by the vast mass of siliceous sinter deposited by the hot springs of Iceland, Colorado, and New Zealand. It has been well established too by the experiments of M. Daubrée,† that certain silicates are readily attacked by water at high temperature and pressure, and suffer decomposition with separation of silica. But, on the other hand, many excellent chemical geologists are satisfied with the feebler power of cold water, and see a sufficient cause of agate-making in the slow but ceaseless action of meteoric waters draining through the rock, decomposing the component silicates, and depositing free silica. Such action must necessarily be slow; so slow, in fact, that, according to Bischof's estimate, the deposition of a layer one line in thickness requires twenty-one years. In order to form one pound of amethyst at least 10,000 lbs. of water must have been introduced into the cavity and evaporated; an action which has been estimated to occupy the vast period of 1,296,000 years.‡ But this represents the formation of only a small stone, whilst in some parts of the world agates of gigantic size have been brought to light. Thus, an agate weighing a centner (110 lbs.)

* "Die Halbedelsteine aus der Familie der Quarze." Von G. Lange, 1868, p. 17.

† "Études sur le Métamorphisme," 1860, p. 89.

‡ "Lehrbuch d. Chem. Geol." vol. iii. p. 636.

was found near Oberstein in 1844. The cavities in which the larger agates occur, were probably formed by the coalescence of several gas bubbles in the original lava.

Whatever agates are found in this country are comparatively small, the finest being the well-known "Scotch pebbles," principally from the Perthshire traps. Larger and finer stones are found in the melaphyre of Oberstein, especially in a hill known as the Galgenberg, or Steinkaulenberg, near Idar, a small town about two miles from Oberstein. As the mother-rock decomposes, the imbedded agates fall out, and these accumulating in the soil attracted attention at a very early date. It was, in fact, this occurrence of agates that led to the systematic quarrying of the melaphyre, and to the planting of agate-mills in the neighbouring valleys. Documentary evidence carries us back four centuries, to A.D. 1454; but how much earlier the Galgenberg agates were worked it is difficult to conjecture.* Only, however, within the last forty years has the industry been fully developed, and this development has unquestionably been due to the large supply of fine stones from South America. In fact, for many years past the agate-quarries of the Galgenberg have not been worked. The writer of this article visited them about ten years ago, under the guidance of an old agate-worker in Idar, but found that they had been long deserted. Adits had been run into the escarpment of the hill, and the softer parts of the melaphyre worked by irregular galleries. Agates, more or less perfect, are scattered in all directions over the floor of the workings, and may be picked out of the walls and roof; but these stones, though pretty enough as specimens, are for the most part scarcely worth cutting, consisting, as they generally do, of a thin rind of chalcedony, lined with a crop of amethyst crystals. A few German agates may, however, be still gathered by the poorer workers, though practically the mines have been abandoned in favour of the South American stones.†

It was in 1827 that some Idar agate workers, who had emigrated to South America with the view of settling in the German colony of St. Leopoldo, observed that the courtyard of a country house was paved with pebbles not unlike the familiar stones of their own hills. Specimens sent home, when cut, polished, and stained, turned out to be beautiful carnelian. The fortunate discoverers collected with ease, from the bed of the Rio Taquarie in Uruguay, several hundredweight of the loose

* "Die Halbedelsteine und die Geschichte der Achat-Industrie," von G. Lange. The writer is much indebted to this work for local and technical details.

† For a description of the quarries as they appeared thirty years ago, see Mr. W. J. Hamilton's paper in "Quart. Journ. Geol. Soc.," vol. iv. p. 209.

stones, and despatched them to Oberstein. From that day to this the South American stones have been constantly imported, and still form the staple material with which the German mills are fed. Numerous other discoveries in Uruguay have been made by emigrants from the agate district of Oberstein, who have devoted themselves to the task of collecting the stones—a task which at the present time is always difficult and often dangerous.

Originally the stones were collected with little trouble, and shipped at little cost; they were found loose in the soil, and brought over simply as ballast. Of late years, however, the trouble and cost have been greatly increased; the agates, becoming scarcer, are found only with difficulty, the owners of the soil demand a rent for the right of search, the Governments of Uruguay and Brazil impose an export duty on the agates, and the shipowners charge for their freight. Large quantities of these so-called "Brazilian stones" are nevertheless still imported, and the impetus given to the agate trade by their discovery half a century ago is not likely to die away.

The agates, having been collected in the interior, are sent down to the coast in waggons drawn by mules or by oxen; they are generally taken to Porto Alegre or to Salto, whence they are despatched to Montevideo and Buenos Ayres in order to be shipped to Europe. Hamburgh, Antwerp, and Havre have at different times been their destination; but at whatever port received they are sent thence by rail to Oberstein. The carnelians, on account of the small size of the pebbles, are packed in cases, but the other stones, unless of exceptional quality, are conveyed in open trucks, like common paving stones. Arrived at Oberstein, they are sorted, and made up in lots, which are exposed for sale by auction in the courtyard of some well-known inn. Advertisements are inserted in the local papers (the *Amts-Blatt für das Fürstenthum Birkenfeld*, or the *Nahethal Bote*), and previous to the sale the agate-workers examine the parcels of stones, chip off fragments, and test them at home with special reference to their capability of receiving colour by processes to be presently explained. The stones, when purchased, are sent to the agate mills, where they are cut and polished on wheels turned by water-power.

In determining the location of the agate industry an abundant supply of water-power was a factor quite as important as the presence of the stones themselves. From the heights of the Hochwald and the Idarwald, in which the Hundsrück culminates, numerous streams roll down with great rapidity, and finally pour themselves into the river Nahe. Of these streams the most important to the agate-worker are the Idarbach and the Fischbach, especially the former. The little Idar is about

1,012 feet above the sea-level at the town of Idar itself, but at Oberstein, where it falls into the Nahe, its height is only 905 feet. In the valley between the two towns, scarce a couple of miles apart, most of the agate-mills are situated. In 1867 there were 153 mills, working 724 stones; and though the greater number of these are in Birkenfeld, some are situated in the adjoining Prussian territory.

Each mill contains from three to five stones, set on a horizontal axle, one extremity of which, passing outside the workshop, communicates with a water-wheel, by which the millstones are set in motion. Most of the older wheels are undershot, but overshot wheels are erected in the modern mills. Each wheel measures from 10 to 18 feet in diameter. As the working is dependent on a due supply of water it formerly happened that the mills were compelled to stand idle during the drought of summer or the frosts of winter; artificial provision is, however, now made for a supply of water during the dry season, and the use of steam has been introduced to a limited extent. When the writer last visited Oberstein, a small engine of 16-horse power was working in the mill of the Gebrüder Purper in Idar; this engine gave motion to five millstones, accommodating ten men, but was capable of turning eight stones, employing sixteen grinders. Another engine was working at Herrstein.

The millstones are made of red sandstone from the Bunter of the neighbourhood of Landstuhl, near Mannheim. Each wheel is about five feet in diameter, and rotates in a vertical plane; the lower half of the wheel moving in a well beneath the floor of the workshop (fig. 3, Pl. II.). The broad edge of the wheel is kept moist by a stream of water constantly trickling down from a launder running above the series of stones. Before being brought into use, the wheels are seasoned by exposure for some time in the open air. Stones fresh from the quarry have been known to suddenly fly to pieces while rapidly rotating; and on two occasions grinders have thus been killed in the Oberstein mills.* The stones generally make three revolutions per second.

When choice stones are to be worked, it is usual to begin by slitting them into shape with steel wheels and diamond powder. The commoner agates, however, are not sawn, but roughly dressed with hammer and chisel, the workman acquiring by long practice great dexterity in striking the stones in the proper direction to insure the desired fracture. The grinding is effected on the broad edge of the red sandstone wheel, which is furrowed with channels corresponding in shape

* Description of the Agate Mills at Oberstein in Germany. "Mechanic's Magazine," 1823, vol. i. p. 199.

with the form which it is desired to give to the object under hand. Sometimes the agate is held simply in the grinder's hand, but usually it is attached to the end of a short stick, and thus applied to the moving wheel. During the rapid rotation of the wheel the siliceous stones are all aglow with a beautiful phosphorescent light, visible even in daylight; and the spectator can hardly bring himself to believe that the carnelians are not red hot. The phenomenon has been studied by Professor Nöggerath.*

One of the most striking, and at first sight painful, features in an agate-mill is the extraordinary position in which the grinders perform their work. Each stone accommodates two men, side by side; but these men, instead of sitting at the wheel, lie stretched in an almost horizontal position, as represented in fig. 3, Pl. II. The workman lies upon a low wooden grinding stool, specially constructed to fit to the chest and abdomen, leaving the limbs free; the hands are engaged in holding and guiding the agate, whilst the feet are firmly pressed against short stakes, or blocks of wood, screwed into the floor; the reaction enabling the grinder to press the agate with much force against the moving millstone. Long experience has shown that in this unnatural position the workman has the greatest command over his work, and the grinding is, in fact, carried on traditionally in the same way as it was certainly done a century ago. Our figure, though copied from a famous work by M. Collini, published in 1776,† fairly represents the agate-grinder as he may be seen to-day at Idar. It might be supposed that the health of the workman would suffer by this constant compression of his chest, but so far from this being the case, the grinders seem to be a strong class of men; they are often to be heard singing cheerfully at their work, and are contented though receiving extremely low wages. It is, in fact, the low value of labour in this rather out-of-the-way district that enables dealers in this country and elsewhere to sell polished agates at excessively low prices.

After having been ground, the agates are polished on cylinders of hard wood or on metal discs, either of lead or of zinc; these are caused to rotate by leather bands connected with the axis of the water-wheel which turns the millstones. Moistened tripoli is employed as the polishing agent. The hollowing-out of vessels, such as bowls; the boring of agate-beads;

* "Philosophical Magazine," (4) vol. xlvii. p. 237.

† "Journal d'un Voyage qui contient différentes Observations Minéralogiques; particulièrement sur les Agates et le Basalte, avec un Détail sur la manière de travailler les Agates." Par M. Collini. The figure is reproduced in Kluge's "Edelsteinkunde," 1860.

and the engraving of cameos, on onyx, are branches of agate-working which are largely practised at Oberstein, but which we have no space here to describe. It remains, however, to notice one of the most interesting departments of the industry.

Beautiful as agates unquestionably are in their natural state, their beauty is, in the judgment of most people, greatly enhanced by the artificial processes of colouring to which the stones are now almost universally subjected by the Oberstein workers. Not that the art of staining is by any means a modern discovery. It was, in fact, known to the ancients, and the matter did not escape the notice of the omnivorous Pliny, though his description is obviously imperfect.* He tells us that the Arabian stones are purified by leaving them for seven days and seven nights in honey. Now the stones might be left in honey till Doomsday without their tint being in any wise improved, and yet not a word is said with respect to any further treatment. If a stone, which has been steeped in honey, be placed in sulphuric acid, the acid entering the pores of the stone decomposes the saccharine matter which has been absorbed, and a deposit of carbon is thus thrown down in a finely divided form in the interstices of the stone, producing a deep black colour. To believe that the ancients stained their agates in this way is to assume that they were acquainted with oil of vitriol; but as it is generally believed that this acid was first obtained by Basil Valentine in the fifteenth century, some writers have suggested that the Roman stone-workers availed themselves of the sulphuric acid naturally exhaled in certain volcanic districts, whilst others again have maintained that the sugar was charred by simple exposure to heat. In whatever manner the ancients effected the colouring, it is certain that the Italian cameo-workers have always been familiar with a process of staining, and these workers were in the habit of visiting Oberstein, from time to time, for the purpose of purchasing the finest onyxes, which they took back to Rome, there to be stained and engraved. The German workers, who sold the uncoloured stones, remained, however, entirely ignorant of the process until the year 1819. It then happened that a native of Idar and one of the Roman stone-engravers got into difficulties in Paris, and were imprisoned together; during their confinement they became communicative, the conversation frequently turned upon agates, in which they had a common interest, and the secret escaped from the loquacious Italian. Shortly afterwards it was conveyed to Oberstein, and, once out, soon became

* See Nöggerath's paper, "Die Kunst Onyxe, Carneole, Chalcedone, und andere verwandte Steine zu färben, zu Erläuterung einer Stelle des Plinius Secundus." ("Neues Jahrbuch," 1847, p. 473.) The passage referred to is in Pliny's "Nat. Hist.," bk. xxxvii. cap. 75.

common property. The art of colouring, so as to produce good onyx from comparatively worthless stone, gave great impetus to the manufacture.

As at present practised, the stones, having been well washed, are usually placed in a syrup of honey and water, or in some cases, in olive-oil. They are then exposed for some time—at least three days, and often longer—to a moderate heat, in a vessel standing in hot ashes or on a German stove, care being taken that the liquid does not boil. When removed they are well washed and placed in sufficient commercial oil of vitriol to cover them, and again exposed to gentle heat. After they have taken colour, they are removed and well washed; and it is often the practice to finally lay them in oil, which improves the lustre. If too strongly stained, the colour may be "drawn" by the action of nitric acid.* The *rationale* of the process of colouring is extremely simple. Certain layers of an agate are found to be porous, whilst others are well-nigh impervious. When, therefore, such an agate is steeped in syrup or in oil, the liquid is absorbed by the porous layers only, and the subsequent treatment with sulphuric acid carbonizes the saccharine or oleaginous matter, and thus produces a deep brown or blackish colour in certain strata, by impregnation with carbon. Some agates never lend themselves to this treatment, and altogether refuse to take colour, whilst others colour in a few hours: the South American stones usually take the colour readily, and hence their great value to the cameo-worker.

It is clear that the essence of this process lies in the differences of texture displayed by the various strata in an agate. Such differences are strikingly seen when a polished section of an agate is exposed to the action of hydrofluoric acid; the different layers are then corroded in different degrees, and a rough surface is obtained, from which Dr. Leydolt has been enabled to print perfect impressions, showing with fidelity every line in the structure of the stone.†

At the same time that the porous layers of an agate are deepened in colour by the process of staining, the intervening non-porous strata appear to be brought out of purer white colour than before. This is probably in many cases the effect of contrast only; but it is known that chalcedony of bluish tint may by the action of heat be converted into a pure white stone. When an agate has been properly stained it usually exhibits alternate bands of strongly-contrasted black and white chalcedony, thus becoming a true *onyx*—a stone greatly prized by the

* "The Science of Gems." By Archibald Billing, M.D., &c. 1867, p. 62. This interesting work contains a view of Oberstein.

† "Denkschriften d. k. Ak. d. Wissenschaften." Vienna, vol. v. p. 107.

cameo-worker, who skilfully engraves a subject in the white layer, which then stands out upon a dark-coloured ground. If the lower stratum, instead of being black, be brown or reddish, the stone is known as a *sardonyx*: large numbers of such stones are cut for setting in rings. The reddish tint of the sardonyx and of the carnelian may be readily developed artificially, and the process of "burning" by which this is effected was indeed known in Germany long before the methods of colouring onyxes were patent. It had often been observed that greyish-coloured agates, after long exposure to sunshine, became reddened, and the effect of artificial heat in developing the colour had likewise been accidentally observed. Experiments were tried in 1813, and since then the stones have been systematically burnt whenever carnelians are required, as has indeed been practised for ages in the East. The German workmen expose the stones for several weeks to the heat of an oven, the temperature being at first very gentle, and then gradually raised. When all moisture has been thus expelled, the stones are moistened with sulphuric acid, and again exposed to heat, the temperature being this time slowly raised to redness. The reddened stone must of course be allowed to cool very gradually.

In 1845 an Idar manufacturer introduced a method of colouring stones bright blue; but this process, unlike those previously described, produces an effect quite unknown among natural stones. Commonly, the agate is steeped first in solution of a ferric salt—a per-salt of iron—and then in ferrocyanide of potassium, or yellow prussiate of potash, whereby a precipitate of Prussian blue is thrown down in the pores of the stone. Other methods are employed, but these will suggest themselves to any chemist; in fact, almost any process yielding a blue precipitate may be applied.

About the year 1855 a green colour was introduced, and chalcedony was thus tinted to resemble the natural chrysophrase. This colour is produced by the use either of chromic acid or of a salt of nickel. Yellow is also a favourite tint among the Oberstein workers, and is commonly obtained by steeping the stones in hydrochloric acid. Of late years various fancy colours have likewise been employed, and even the aniline dyes have been pressed into the lapidary's service. Such tints are, however, fugitive, and are certainly to be eschewed as utterly unnatural, and therefore to most mineralogists little short of repulsive.

It is unnecessary to follow any of the minor branches of the agate industry, but in dismissing the subject let it not be forgotten that it is an industry which, in the neighbourhood of Oberstein and Idar, gives employment to some three thousand hard-working and contented people.

Found originally in the interior of Uruguay; brought first to the coast at much trouble, and then shipped to Europe; conveyed by train to Oberstein, and there sold by auction; cut, ground, polished, and stained by the skilful German lapidaries; and finally distributed through agents to the fairs, watering-places, and chief towns on the Continent, in England, and even in America,—such, in brief, is the history of by far the larger number of agates which at the present day are found in the market. If, knowing this, we are unable to regard them as indigenous products of the locality in which they are sold, surely they are still worth treasuring for their own sake. Beautiful, durable, and marvellously cheap, they are justly popular as ornamental stones; and it is hoped that the effect of this article will be to encourage, certainly not to injure, the branch of industry which they represent. Nor are they less instructive to the scientific student. It is hard to find any polished section of agate which does not offer enigmas as to its genesis that the wisest among us must confess himself unable to fully solve. "Agates, I think," says Professor Ruskin, "confess most of their past history." * But in spite of what has been already deciphered, this history yet remains in most cases to be read. Mr. Ruskin himself has contributed to the "Geological Magazine"† some singularly suggestive papers touching upon the subject, illustrated by tinted plates of agates, full of truth and beauty. By calling attention to the subject afresh, though all too briefly in the present article, the writer trusts that inquiry may be stimulated and interest quickened in the much-misunderstood subject of Agates and Agate-working.

DESCRIPTION OF PLATE.

FIG. 1. Section of Agate, showing inlet of infiltration (*a*), in support of Prof. Nöggerath's hypothesis.

FIG. 2. Section of agate, showing both horizontal and concentric layers, as seen in many stones from Uruguay.

FIG. 3. Agate-grinder of Oberstein at work.

* "The Ethics of the Dust," p. 190.

† "On Banded and Brecciated Concretions," a series of papers in the "Geol. Mag." for the years 1867 to 1870. Some of these illustrations have been recently reproduced in Mr. Ruskin's "Deucalion," 1876.

CONDITION OF THE LARGER PLANETS.

By RICHARD A. PROCTOR, F.R.A.S.

M. VOGEL'S recent researches into the spectra of the planets are regarded by him as affording evidence unfavourable to the opinion that the planets Jupiter and Saturn are still so intensely hot as to shine in some degree with inherent light. Although it is not at all necessary for the general theory which I have advocated respecting the condition of the larger planets that any portion of their lustre should be regarded as inherent, yet as Vogel's conclusion does bear to some degree on one of the arguments which have been urged in favour of this theory, the opportunity seems convenient for summing up these arguments and discussing briefly the considerations on which M. Vogel bases his objection.

I would remark at the outset that I do not by any means share the opinion of some who, in dealing with this question, and other questions of a like nature, have said that it matters very little what theory is adopted so that it is a convenient working hypothesis, a string, so to speak, on which to thread the observations. It will be found that this method of viewing matters is never expressed except by persons who have fallen into the habit of accumulating observations without reasoning upon them,—in fact, without utilising them. Observation is with them not a means but an end. It seems to me, or rather I may speak more confidently and say that the whole history of science proves, that the real value of observation and experiment lies not in themselves, but in what may be deduced from them. They are the raw material whence scientific knowledge is to be manufactured. It is not the object of a theory to afford a convenient means of classifying observations and also to suggest occasion for making them, but to educe their real significance; and the sole reasonable object of observations is to suggest the true theory and to afford the means of testing and rejecting false ones. To assert that it matters little what theory is suggested so long as it affords a convenient means of classifying observations, is as absurd in reality as it would be to assert that it

matters very little in what manufacture raw materials of a particular kind are employed, so that the manufacture affords a ready means of sorting them away and making room for fresh stores of them. The object of manufacture is to make articles which shall have real value, and raw materials are solely of use in so far as they can be employed in the manufacture of articles of such a nature. In like manner the object of theorizing or reasoning is to discover actual truths, and observations are only useful in so far as they enable us to discover such truths. The mere observer who argues that observation and not reasoning is real science, may be compared to an organ-blower who should argue that his work, not that of the organist, constituted real music. The organist cannot play without wind, the manufacturer cannot get on without raw materials, and in like manner Kepler would never have established his laws without the observations collected by Tycho Brahé, nor would Newton have discovered the law of gravity without the raw material collected by Flamstead; but as it is important in organ music that the wind be exhausted in melody not in mere noise, and important in manufacture that the raw material be employed to make useful not useless articles, so it is and has been a matter of considerable importance whether observations have been idly worked up in false systems like those of Ptolemy or Descartes, or wisely used to ascertain the truth, as by Copernicus, Kepler, or Newton.

The theory which is now to be considered is this, that the planets Jupiter and Saturn are still in a state of intense heat, being at a much earlier stage of planetary development than our earth or those four companion orbs, Mercury, Venus, Mars, and the moon (in one sense more specially a companion than the others) which have been called the terrestrial planets.

At the outset it may be well to consider the evidence for the only other theory which has been advanced on the subject—the theory commonly accepted with apparently as little question as though it had been the result of long and profound investigation, had been tested in every possible way, had been weighed and not found wanting by all the ablest astronomers the world has known. This is the theory that Jupiter and Saturn are bodies in the same condition as our earth.

It is not easy to find any reasoning whatever bearing upon this theory. It would seem almost that so soon as Copernicus had shown that the planets do not travel round the earth as a centre, but the earth with the planets travel around the sun, the conclusion was at once adopted that the earth and the planets are of necessity bodies of the same nature; and that as no one was at the pains to question this doctrine, it became gradually regarded as one that had been established by demon-

strative evidence. The few instances of anything like reasoning which I have been able to find scattered here and there in books of astronomy amount to what follows:—First, because Jupiter and Saturn are planets, and the earth is a planet, therefore those planets are like the earth. (This argument is open to the objection that it begs the question, which is, Whether other planets resemble the earth.) Jupiter and Saturn are globes like the earth (also like the sun and moon). They rotate on their axes, and therefore if they are inhabited worlds like the earth, they have day and night, and in that respect are like the earth. They circle around the sun, and thus if they are worlds like the earth, they are like the earth in having a year; also in having seasons, since their axes are not perpendicular to the planes in which they travel. It would be absurd to suppose that globes so magnificent were made for no special purpose, but we can conceive no special purpose they can subserve except to be the abodes of life; therefore they are worlds like our earth (though the sun, constructed on a still more magnificent scale, is certainly not such a world, or the abode of life). Their moons are manifestly intended to make up to them for their remoteness from the sun (only, when we calculate how much light these moons reflect to their primaries we find that they supply but a small fraction of the amount we receive from our moon). The rings of Saturn were manifestly intended for the benefit of Saturn's inhabitants (though they only reflect light to the summer hemisphere of the planet, and besides turning their darkened side to the other hemisphere, cut off the whole of the sun's light for many months, in some cases for several of our years, in succession). The belts on Jupiter and Saturn may be likened again to our trade wind zones, to which, however, they bear not the remotest resemblance, whether we consider their condition at any given time, or the rapid changes they undergo from time to time. In fine the arguments used by the few writers who have condescended to present even a show of reasoning in favour of the theory that Jupiter and Saturn resemble our earth in condition, amount practically to this—that, assuming all planets to be generally similar, Jupiter and Saturn are like our earth in general respects, in which case they also resemble her in several details.

I do not consider it necessary to discuss Whewell's theory that Jupiter and Saturn are intensely cold planets, because it is professedly based on the theory that they are formed of such terrestrial elements as would, if in the same condition as upon the earth, have the observed density of Jupiter and Saturn, and that these substances, being further removed from the sun, are correspondingly refrigerated. There is not a line of direct reasoning, either *a priori* or *a posteriori*, in Whewell's

chapters on the larger planets—only reasoning which depends on the assumptions which had been made by those whom Whewell proposed to controvert. In fact his theory may be regarded, and was probably regarded by himself, as merely a *reductio ad absurdum* of the unreasoning faith of those who had long held unchallenged the belief in the habitability of all the planets.

I proceed to indicate the leading arguments for the theory that Jupiter and Saturn are still intensely hot, noting first that I do not propose to discuss the details of the various arguments* (which I have already done elsewhere), and secondly that the arguments are not dependent one upon the other, but severally independent, so that if any seem weaker than the rest, the conclusion is not on that account invalidated, but the weight of evidence only *pro tanto* diminished. It is important to notice this, because many who, in examining a series of arguments, recognize, or suppose they recognize, some weakness in the evidence of one or other argument, are apt to infer that the conclusion is to the same degree invalidated as it would be if the arguments were dependent, and therefore each one essential to the establishment of the conclusion.

The first argument for the theory is that derived from the now accepted hypothesis of the growth or development of the solar system. It is rendered to all intents and purposes certain, as well from the evidence of the earth's crust, as from that given by the movements of the sun, planets, asteroids, and satellites, that the solar system was developed from a former nebulous condition. The process of development may have been that conceived by Laplace in his nebular hypothesis, which may be described as the contraction theory, or that recently suggested by meteoric discoveries, which may be called the accretion theory, or, far more probably, the solar system was formed by combined processes of contraction and accretion. But in any case the planets as severally formed were intensely heated, partly vaporous, partly liquid bodies, the larger being the more heated. It is no longer supposed, as in Laplace's time was the case, that the outermost planets were fashioned first. They may have begun to be formed first—this, indeed, is altogether probable—but the vastness of their bulk suggests that they went on gathering in matter and contracting (forming in the process their systems of moons) long after such small planets as Mars or Mercury, though begun much earlier, had gathered in their entire substance. It seems indeed not at all improbable

* I may, perhaps, be permitted to remark here, that the details of many among the arguments here indicated will be found fully discussed in my Lecture delivered at Glasgow on November 9 last, and published by Messrs. Collins, of that city.

that neither Jupiter nor Saturn have quite passed through even the first stage of planetary development, the ring-system of Saturn being suggestive of matter as yet not completely worked-up, so to speak, in that planet's system. But whatever uncertainty rests on this question there is none as to the original intense heat of those larger planets. They must have been far hotter when first formed than was our earth at the corresponding stage of her development. Nor is it at all open to doubt that each stage of cooling would be much longer in the case of these planets than the corresponding stage of our earth's cooling.* Jupiter contains 340 times as much matter as the earth, so that if the two orbs were of the same density Jupiter would have a diameter seven times as great, and a surface about forty-nine times as great, as the earth's. He would radiate, therefore, if at the same temperature, forty-nine times as much heat; but he would have about 340 times as much heat to part with for each degree of cooling; hence his rate of cooling would be slower in the proportion of about 7 to 1. Jupiter appears actually to have a much greater volume than has been here supposed, his diameter exceeding that of the earth nearly eleven times, and his surface exceeding hers about 115 times. This would still leave his rate of cooling slower in the proportion of about three to one. But inasmuch as it is certain that if formed of the same material, Jupiter, when at the same stage of cooling, would be much denser than the earth (because of his greater attractive energy), our assumption rather falls short of the truth than exceeds it. The argument next to be considered will sufficiently indicate this. To complete the present argument it is only necessary to add that the various stages of cooling through which our earth has already passed have certainly required hundreds of millions of years, wherefore the corresponding stages for Jupiter would require *seven* times as many hundreds, and the total period required by Jupiter to

* The argument here used was first advanced by Sir Isaac Newton. "A globe of iron an inch in diameter," he says, "exposed red hot to the open air, will scarcely lose all its heat in an hour's time; but a greater globe would retain its heat longer in the proportion of its diameter, because the surface (in proportion to which it is cooled by the contact of the ambient air) is in that proportion less in respect of the quantity of the included hot matter; and therefore a globe of red hot iron equal to our earth, that is about 40,000,000 feet in diameter, would scarcely cool in an equal number of days, or in about 50,000 years. But I suspect that the duration of heat may, on account of some latent causes, increase in a yet less proportion than that of the diameter; and I should be glad that the true proportions were investigated by experiments." Buffon (according to Bailly) made experiments of the kind, with results confirming Newton's opinion.

reach the earth's present condition of development would exceed the time during which our earth has endured, from her beginning until now, *six* times, even though Jupiter at his beginning were no hotter than the earth. As he was certainly much hotter, it may fairly be said that he would require thousands of millions of years to reach the stage which the earth has reached after hundreds of millions of years; and that, if the two planets were both fashioned at the same time, Jupiter must still require thousands of millions of years before he will have attained to that stage of planetary life through which our earth is now passing. Saturn would not be so far in the rear of our earth because his mass does not exceed hers so greatly. Still he contains nearly a hundred times as much matter, and must be regarded as in all probability, so far as this first argument alone is concerned, hundreds of millions of years behind our earth in point of development.

The second argument is that derived from the small density of Jupiter and Saturn. Jupiter has a volume exceeding the earth's about 1250 times, but a mass only exceeding hers 340 times. Saturn's volume exceeds the earth's 700 times, his mass only 99 times. Jupiter's mean density is therefore about one-fourth, Saturn's about one-seventh, of the earth's. Science no longer accepts the belief that either planet is formed in the main of different materials, spectroscopic analysis having demonstrated the existence of a general uniformity of structure throughout the solar system. Neither can science any longer admit the possibility that Jupiter and Saturn are hollow globes, experiment having proved that under the pressure exerted by the mass of either planet, a substance a hundred times stronger than the strongest steel would be perfectly plastic throughout the greater portion of either planet's interior, so that hollow spaces, if they could be formed for a moment, would fill up just as an open space formed for a moment by thrusting water on one side fills up as the water flows back to its normal position. We are forced then to believe that there is some cause at work to overcome the natural tendency of the planet's mass. Doubtless this cause is the same which operates to prevent the sun's mighty mass from concentrating, as it would, into an intensely dense globe, were its gravitating energies left unresisted—viz., intense heat. The sun is, of course, very much hotter than Jupiter and Saturn; his heat, indeed, overcomes a very much greater contractive energy. But Jupiter and Saturn must be very much hotter than the earth.

The third argument is based on the telescopic evidence of the existence of a very deep cloud-laden atmosphere surrounding each of the planets Jupiter and Saturn.

It is first to be noticed, as respects this argument, that the

general aspect of the belts of Jupiter (Saturn is too far off for similar appearances to be noted) indicates the presence of rounded masses of cloud floating in a deep atmosphere. These rounded masses can only be seen as such on the middle parts of the disc, but there their appearance shows unmistakably that they are really round,—that is, not merely round in appearance, as a circle is round, but round as a globe is round. No one who has studied Jupiter with a powerful telescope can for a moment doubt that some at least among the cloud-masses which are seen in his disc are roughly globular in shape. It is sufficient if only one of these masses has really had such a shape, for though any number of flat objects may float in a sea which so far as they were concerned might be shallow, yet if it is known that a single object has floated in it which was not flat, but on the contrary had great length, and breadth, and thickness, we know that the sea must be a deep one. Some among the rounded clouds of Jupiter, which not only by their shape, but by their shading, indicate a globular figure, would, if actually globular, require an atmosphere five or six thousand miles deep at the very least. The atmosphere may not be so deep as that, or may be very much deeper. Certainly it would at once remove the difficulty last considered if we could suppose the cloud-bearing atmosphere of Jupiter to be thirteen or fourteen thousand miles in depth, for then the solid globe within would not differ very much in mean density from the globe of our earth. But supposing we assume, as the result of the actual telescopic aspect of the cloud-belts, the depth of the atmosphere to be but about 2000 miles, which would be less than the apparently minute diameter of one of the satellites, we should even then find that under the tremendous pressure exerted by Jupiter's attraction the lower strata of such an atmosphere, if composed of any gases known to us, and at the temperature of our own air even in the torrid zones, would be simply compressed into the solid or liquid form. At least they could not continue to obey the laws which perfect gases obey under pressure. Assuming the pressure at the visible limit of the cloud envelope to be less than one-thousandth part of the pressure of our air at the sea-level, then fifteen miles below that limit the pressure would be equal to that of air at our sea-level, fifteen miles lower one thousand times as great, fifteen miles lower one million times as great, and fifteen miles lower yet, or still only sixty miles below the visible limits of the cloud envelope of Jupiter, the pressure would be one thousand million times as great as at our sea-level. The density, if only the gases composing that atmosphere could remain as perfect gases, would be more than a million times greater than the density of water, and thirty or forty thousand times greater than the density of

the heaviest known elements. Of course there is no such pressure, no substance exists at that density, sixty miles below the visible limits of Jupiter's atmosphere, nor ten thousand miles lower yet. No gas could remain as such at ordinary temperatures beneath a pressure which would make it as dense even as water; and if strata could and did exist in Jupiter at the higher pressures and densities named, he would weigh many thousand times as much as he actually does. But we are again forced to the belief that, unless his atmosphere is made of substances altogether different from any with which we are acquainted, there must be some power at work to prevent the compression which would otherwise inevitably result from the tremendous attractive energy of Jupiter's mass. That power can be no other than the fierce heat with which his whole frame, his atmosphere (and all but the exterior strata outside the outermost cloud-layers) are instinct.

It appears to me that a fourth argument of very great force can be derived from the cloud-belts in the atmosphere of Jupiter and his brother giant, Saturn.

The existence of well-defined belts is proof positive of the existence of different rates of rotational motion. For instance, we cannot explain our own trade-wind zones, without taking into account the different velocities due to rotation near the equator and in high latitudes,—matter flowing towards the equator lags behind, matter flowing from it travels in advance, and in either case zones are formed. If a similar explanation could be given of the belts of Saturn and Jupiter doubtless they would be accounted for. But where are we to find the varieties of heat in various latitudes of either planet which could account for the multitudinous belts sometimes seen? or how, if the sun's slow action on these remote and large planets were in question, could we account for the rapid formation and dissipation of cloud-belts? The largeness of these planets is a point of importance to the argument, because the larger a planet the less, *cæteris paribus*, is the variation of temperature for any given difference of latitude measured as a distance in miles. If then we cannot look for the required differences of rotational velocity where we find them in our earth's case, it is clear we must turn to difference of rotational velocity on account of difference of distance from the axis, not at places in different latitudes, but in places at different levels. In other words, we must conceive that under the action of the planet's intense heat vaporous disturbances of the nature of uprush and downrush are continually taking place. Matter rushing upwards from low levels to high levels, where the rate of rotation is very much greater, lags behind, while matter rushing downwards is carried in advance, and thus cloud zones are formed.

A fifth argument is derived from certain considerations depending on the behaviour of sun-raised cloud-masses in our own air, both with regard to the progress of the day, and with regard to the progress of the year. We know that speaking generally the clouds change as the day progresses, and that this is specially the case in those regions of the earth where regular zones exist. The sun, in tropical regions, rises in a clear sky and quickly gathers clouds together; these remain till the afternoon, when they become dissipated (usually with violent disturbance, electrical and otherwise), and the sun sets in a clear sky. As seen from Venus or Mercury the cloud-belt would extend across the middle of the earth's disc, but would not reach to the edge, either on the west or sun-rising side, or on the east or sun-setting side. Nothing of the kind is observable in the cloud-belts of Jupiter. Not only do they extend right across (though becoming fainter near the edges because seen through deeper atmosphere), but cloud masses have been known to remain, quite recognizable in contour, during many Jovian days, and even for forty or fifty of our own much longer days. So also with regard to the year. In Jupiter's case, indeed, the effect of annual changes in the arrangement of clouds would not be recognizable, simply because the planet's equator is nearly coincident with the plane of Jupiter's orbit. But in Saturn's case the inclination of the equator is considerable; so that, as seen from the sun, the equator passes far to the north and far to the south of the centre of the disc, during the summer of the northern and southern hemispheres, respectively. We should expect to find these changes accompanied by corresponding changes in the position of the central zone of clouds. Our terrestrial tropical cloud-zone, being sun-raised, follows the sun, passing north of the equator during our northern summer, until at midsummer it reaches the tropic of Cancer, and passing south of the equator during the southern summer, until at midsummer (December) it reaches the tropic of Capricorn. But instead of the mid-zone of Saturn behaving in this way, it remains always equatorial.

Another (the sixth) argument, and in my opinion an argument altogether irresistible, is derived from the changes which have taken place from time to time in the outline of the planets Jupiter and Saturn, *unless* observations made by most skilful astronomers, and with instruments of considerable power, are to be rejected as unworthy of trust. I refer in particular, first to the observations by Admiral Smyth, Sir R. Maclear, and Professor Peacock, of the reappearance of the second satellite of Jupiter a few minutes after it had apparently made its complete entry upon the planet's disc at the beginning of a transit; and secondly, to the fact that Sir W. and Sir J. Her-

schel, Sir G. Airy, the Bonds and Coolidge in America, and several of the Greenwich observers, have recognized the occasional assumption by Saturn of what is commonly called his "square shouldered" aspect. These observations are far too well-authenticated, and were made by observers far too skilful, to be open to doubt or cavil. They cannot possibly be explained except by assuming that the outlines of Jupiter and Saturn are variable to such an extent that the variations appreciably affect the figure of the planets. Such variations, involving differences of level of two or three thousand miles, are utterly incredible, and in point of fact impossible, in the case of planets like our earth. The heat generated by such changes would of itself suffice to melt and in large degree to vaporize the crust for many thousands of square miles around the scene of upheaval or depression, so that we should thus have, but in another way, the heat which my theory indicates. On the other hand, such changes of outline in a planet whose apparent outline is not formed by its real surface, but by cloud layers thousands of miles above the real surface, are very easily explained. Nay, they are to be expected (though only as rare phenomena). We know that cloud-belts sometimes form, or are dissipated, rapidly on the face of the disc. Equally, therefore, they must sometimes form or become dissipated rapidly at parts of the planet so placed as to form the apparent outline. There would then be a rapid change of outline, such as must have occurred in the case of the apparent reappearance of Jupiter's second satellite. Slower changes in the cloud-belts would correspond to the changes of shape observed in Saturn's case, and would explain Schröter's observation that at times the outline of Jupiter has seemed to him irregular, as if the planet's surface were partially flattened. Other observations tending in the same direction, as peculiarities in the shape of the shadows of Jupiter's satellites on the planet, in the shape of Saturn's shadows on his rings, and so on, are of less weight perhaps than those already considered, but unless those who recorded them (including some of the most skilful observers known) were entirely deceived, such observations can only be fully explained by the great depth of the cloud-laden atmosphere which surrounds the giant planets.

Lastly, there is the argument derivable from the peculiar brightness of the planets Jupiter and Saturn. These planets might be so hot as to glow with an intense light and heat, yet no part of their light might be discernible, the deep cloud-layers simply cutting it off before it reached the outermost or visible cloud surface. Or this might happen with all the rays except those which travelled the shortest way through the cloud-layers. In the former case we should perceive some of the inherent light of these planets, in the latter we should only

perceive their inherent light in the central parts of the disc, which would therefore look brighter than the parts near the edge. This last is the phenomenon actually observed, but it does not of itself suffice to prove (though rendering it highly probable) that the light from the middle portion of the disc is *in part* inherent. Nevertheless the planet's surface might, as I have already said, be intensely hot, and yet no trace of the inherent light be perceptible by us. That, however, could only happen because of the existence of very deep cloud-layers entirely shrouding the glowing planet, and in this case, as the clouds would probably —like our own clouds—have a much higher reflective capacity than rock surfaces have, we should expect to find the planets Jupiter and Saturn shining much more brightly, though only by reflected light, than they would if their surface resembled that of our own earth, or Mars, or Jupiter. Now the following table from Zöllner's "Grundzüge einer allgemeinen Photometrie des Himmels," gives very interesting evidence on this point:—

Snow just fallen	reflects	about	783	parts	of 1000	of incident	light;
White paper	"	"	700	"	"	"	"
Jupiter's surface	"	"	624	"	"	"	"
Saturn's surface	"	"	498	"	"	"	"
Uranus's surface	"	"	640	"	"	"	"
Neptune's surface	"	"	465	"	"	"	"

whereas

White sandstone reflects	only about	237	parts	of 1000	of incident	light;
Clay marl	"	"	156	"	"	"
Mars's surface	"	"	267	"	"	"
The Moon's surface		"	174	"	"	"

We may take Jupiter and Saturn together, and Mars and the moon; getting average reflective power of giant planets : that of small planets :: 561 : 220; or the giant planets, if they owe their light entirely to reflection, have a reflective power more than $2\frac{1}{2}$ times greater than that of the small bodies, Mars and the moon. As the sea regions of Mars are observably darker than his land regions, it is probable that our earth, if her light could be estimated in the same way (by an observer on Mercury or Venus) would be found to have a smaller average reflective power than Mars, her seas being so much larger.

We are forced by this argument to one of two conclusions— either Jupiter and Saturn shine in part by inherent light, or they are so thoroughly cloud-wrapped as to have a very high reflective power. Either conclusion would agree equally well with the theory I have advocated, though, of course, the former would be much more effective, and would in fact be quite decisive in its favour.

For my own part, I think that the photometric evidence renders it very probable that a slight portion of the light of the planets Jupiter and Saturn is inherent; and I think the colour of the equatorial belt of Jupiter and its changes of colour correspond with this view. I should be disposed to assign, as the reflective power of Jupiter (his *albedo*, as Zöllner calls it) about 500, or more than twice the reflective power of white sandstone, and thus to attribute about one-fifth of Jupiter's light to the planet's inherent lustre. (In Saturn's case Zöllner's observations are much less satisfactory—his measures indeed of the planet's total light were probably even more satisfactory than in Jupiter's case, but it is exceedingly difficult to take properly into account the effect of the ring-system, which, though very much foreshortened when Zöllner made his observations, must nevertheless have appreciably affected his results.) All the known facts accord well with this view.

Certainly the spectroscopic evidence recently obtained by Vogel, or rather the general spectroscopic evidence (for his results are not new) is not opposed, as he seems to imagine, to the theory that the actual surface of Jupiter is intensely hot. His argument is that, because dark lines are seen in the spectrum of Jupiter, which are known to belong to the absorption spectrum of aqueous vapour, the planet's surface cannot be intensely hot. But Jupiter's absorption spectrum belongs to layers of his atmosphere lying far above his surface. We can no more infer—nay, we can far less infer—the actual temperature of Jupiter's surface from the temperature of the layers which produce his absorption spectrum, than a being who approached our earth from without observing the low temperature of the air ten or twelve miles above the sea-level could infer thence the temperature of the earth's surface. There may be, in my opinion there almost certainly *are*, layers of cloud several thousand miles deep between the surface we see and the real surface of the planet. I do not suppose that the inherent light referred to above as probably received from Jupiter, is light coming *directly* from his glowing surface, but the glow of cloud masses high above his surface, and illuminated by it,—perhaps even the glow of cloud-layers lit up by lower cloud-layers which themselves even may not receive the direct light emitted by his real surface.

To sum up, it appears to me, that a theory to which we are led by many effective and some apparently irresistible arguments, and against which no known facts appear to afford any argument of force, should replace the ordinary theory, originated in a haphazard way, and in whose favour no single argument of weight has ever been adduced. Since it appears,—(1) that if the accepted theory of the development of our system is

true, the large planets must of necessity be far younger, that is hotter, than our earth and other small planets; (2) that if made of similar materials, those planets must of necessity be far denser than they actually are, unless they are very much hotter than the earth; (3) that the atmospheres (judging of their depth from the planet's appearance) would be compressed into solid and very dense matter under the planet's attraction unless exceedingly hot throughout their lower layers; (4) that the belts and their changes imply the uprush and downrush of heated masses of vapour through enormous depths of atmosphere; (5) that the cloud-belts neither change with the progress of the day nor of the year in the large planets, but in a manner in no way referrible to the sun, and are therefore presumably raised by the intense heat of the planet's own substance; (6) that so remarkable are the changes taking place in the atmospheres of Jupiter and Saturn, as appreciably (even at our enormous distance) to affect the figure of those planets; and (7) that the planets shine with more than 2½ times the brightness they would have if their visible surface were formed of even so lustrous a substance as white sandstone—I think the conclusion is to all intents and purposes demonstrated that the planets Jupiter and Saturn really are in a state of intense heat. If they ever are to be the abode of life, they will probably not be ready to subserve that purpose for hundreds of millions of years.

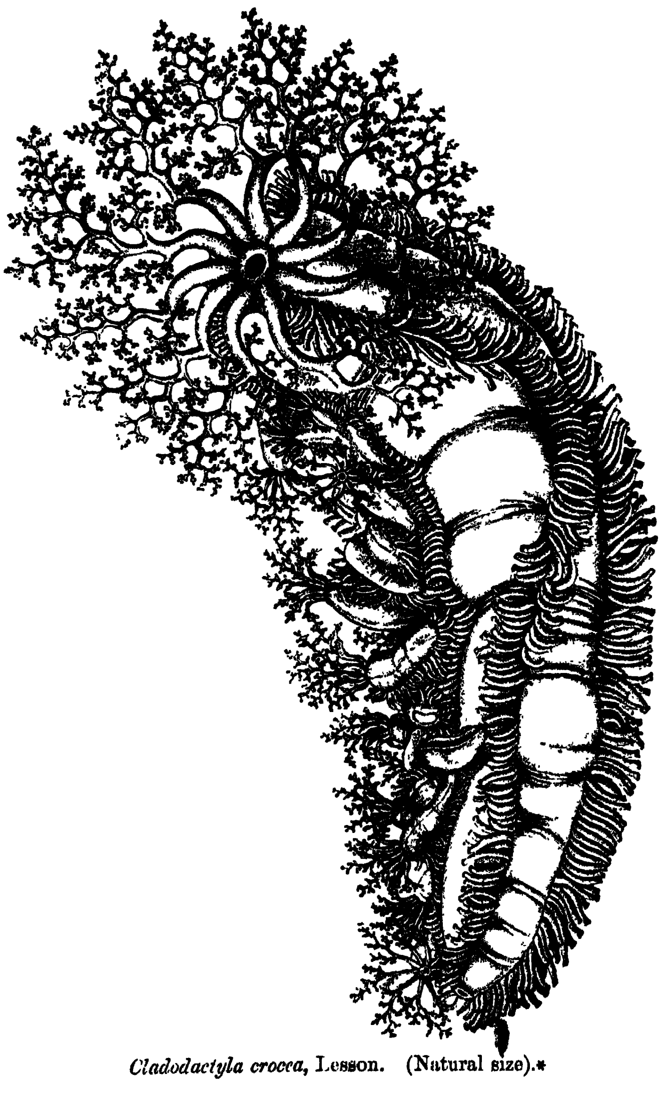
NURSING ECHINODERMS.

As most of our readers are probably aware, the mode of development general among the Echinodermata is not direct, but complicated by the intervention of what has been called a "pseudembryonic stage"—a minute organism swimming by the aid of cilia, quite distinct in appearance from its parents, and producing the adult form by a process analogous to gemmation. The more striking forms of pseudembryos, when originally discovered, were regarded generally as independent organisms, and their peculiarities of structure led to their being taken as the types of several genera of animalcules, to which the names of *Pluteus*, *Bipinnaria*, *Auricularia*, &c., were given. In some cases, indeed, the young animals could hardly be said to be true pseudembryos in the proper sense of the term, as their structure was merely complicated by certain provisional organs which were cast off when the perfect form was attained; and in some cases the development was found to be absolutely direct, even in species nearly allied to others which had well-marked pseudembryos, just as we find among the Crustacea that the mode of development of nearly related species sometimes differs in the earlier stages.

During the voyage of the *Challenger*, just completed, great numbers of interesting Echinodermata were procured, and among those obtained in the Southern Ocean there were many which not only presented an exception to the ordinary mode of development in their nearest allies, in the fact of the young animals being produced directly, and apparently without the intervention of a pseudembryo, or the formation of any provisional organs, but also exhibited certain curious arrangements of various parts, adapting these to furnish protection to the young during their helpless early stages. In some instances, indeed, the analogy of the arrangements with those prevailing in the pouched mammals of Australia is so strong as to justify the application of the term "marsupial" to these Echinoderms. Sir C. Wyville Thomson has just described in the "Proceedings of the Linnean Society" eight examples of these protective

associations between the mother and the young in the Southern Echinoderms, and as the subject is one of considerable interest and importance we have thought that a summary of his results might not be wholly unacceptable to our readers.

FIG. 1.



Cladodactyla crocea, Lesson. (Natural size).*

* We are indebted to the kindness of the President and Council of the Linnean Society for the use of this and the other illustrations to this article.

In the order of Sea Slugs, or Holothuroidea, Sir C. Wyville Thomson notices two species in which the development appears to be direct; but the arrangements for the shelter of the young are very different in them. One of them, which is identified with the *Cladodactyla crocea* of Lesson, has a curious nursery for its offspring, and not an incubatory pouch. It is a small and elegant species, attaining a length of about 4 inches, and a diameter of 1⅓ inch; its colour is a bright saffron yellow, and it was found abundantly adhering to the fronds of the gigantic sea-weeds (*Macrocystis*) floating in water from five to ten fathoms deep in Stanley Harbour, East Falkland Island. The oral tentacles, ten in number, are long and delicately branched; and the skin is thin and semitransparent, allowing the muscular bands and other internal parts to be plainly seen. Five ambulacral rows of numerous and well-developed tentacular feet traverse the body from end to end, but not at equal distances apart; three of them are approximated on one surface of the animal and two on the other, the space between the two groups on each side being considerably wider than that between any two ambulacra of the same group. The tentacular feet in the three approximated rows are larger than the others, and constitute, at all events in the female, the regular means of locomotion; in this sex the two other (dorsal) rows subserve a totally different purpose, forming, as it were, the fences of the nursery in which the animal carries about its young. These tentacles are short, and although they are provided with sucking discs, the calcareous framework of the latter is in a rudimentary condition.

It is along these two dorsal rows of tentacles, and indeed adhering to them, that the young animals are carried about by their mothers until they have arrived at a condition to shift for themselves, which must be comparatively late in life. Sir C. Wyville Thomson observed them still occupying this position of dependence when they were nearly half as long as their parents, and he describes the appearance of the mothers "with older families" as peculiarly grotesque—"their bodies entirely hidden by the couple of rows, of a dozen or so each, of yellow vesicles, like ripe yellow plums, ranged along their backs, each surmounted by its expanded crown of oral tentacles." The young animals are nearly perfect miniatures of their parents, except that, as might be expected, the tentacles of the two dorsal rows are quite rudimentary, or barely indicated; the tentacular feet of the other three ambulacra, on the contrary, are very early developed, and it is by their means that the adhesion to the dorsal tentacles of the mother is effected. The placing of the young animals was not observed, but it seems probable that "the eggs are impregnated either in

the ovarial tube or immediately after their extrusion, that the first developmental stages are run through rapidly, and that the young are passed back from the ovarial opening, which is at the side of the mouth, along the dorsal ambulacra, and arranged in their places by the automatic action of the ambulacral tentacles themselves."

A still more curious and interesting example of this direct mode of reproduction, coupled with the presence of a complete incubatory cavity, is furnished by a small Holothuroid which was dredged in February in seventy-five fathoms of water at the entrance of Corinthian Harbour (otherwise called Whiskey Bay) in Heard Island, to which Sir C. Wyville Thomson gives the unenviable distinction of being, so far as he knows, "the most desolate spot on God's Earth." It belongs to the curious genus *Psolus*, of which we have one or two British species, and which is characterized by having the rather short body encased in calcareous scales and plates, with the exception of a soft disc occupying a great part of its lower surface, and bearing three rows of ambulacral tentacles, on which the animal crawls, very much after the fashion of a Gasteropod mollusc. The mouth, with its surrounding ten tentacles, and the vent, open on the upper surface, or at least quite separate from the ambulatory disc.

The species upon which Professor Wyville Thomson's observations were made, measures rather more than an inch and a half in length, and is considered by him to be nearly allied to the northern *Psolus operculatus*, of which he thinks it may possibly turn out to be only a variety. The oral aperture is furnished with a small low pyramid, formed of five closely fitting calcareous plates, which close it accurately when the mouth with its surrounding tentacles is withdrawn within the test (fig. 2); the anal aperture is closed by a similar but less regular valvular apparatus (figs. 2 and 3).

In the female the middle of the back is occupied by a sort of saddle (fig. 2.) composed of large finely granulated calcareous plates of rather irregular form, but fitting together with tolerable accuracy, and from this character the animal has been provisionally named *Psolus ephippifer*. It is here also that we find the peculiarity which renders this species particularly interesting in connexion with the subject at present before us. "On removing one or two of the central plates," says Sir C. Wyville Thomson, "we find that they are not, like the other plates of the perisom, imbedded partially or almost completely in the skin, but that they are raised up on a central column like a mushroom or a card-table, expanding above to the form of the exposed portion of the plate, contracting to a stem or neck, and then expanding again into an irregular foot, which is imbedded in the soft

tissue of the perisom; the consequence of this arrangement is that when the plates are fitted together edge to edge, cloister-like spaces are left between their supporting columns. In these spaces the eggs are hatched, and the eggs or the young in their early stages are exposed by removing the plates (fig. 3)." This therefore is a true special marsupium or incubatory cavity, and as it occupies the greater part of the dorsal surface and its passages advance close to the edge of the mouth where the ovarial aperture is situated, the eggs pass at once into the protective cavities, without any exposure to external dangers. As the young animals increase in size, the surface of the marsupium

Fig. 3.

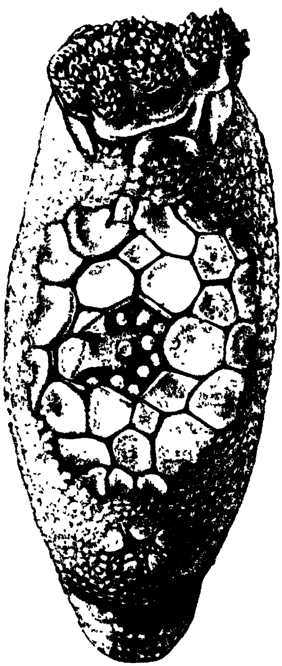
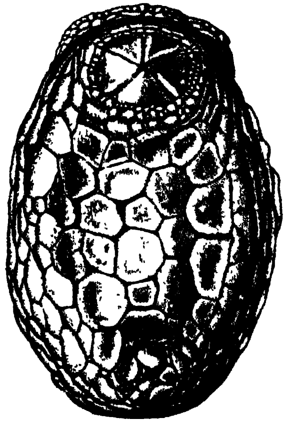


Fig. 2.



Psolus ephippifer, Wyv. Thomson. About three times the natural size.

becomes more and more convex, and the plates enclosing it, which at first fitted accurately together, separate more and more from each other, until at length they are wide enough apart to permit the escape of the young animals. All the young in the same marsupium appear to be nearly of an age. In the male the middle of the back is occupied by a saddle like that of the female, but the plates composing it are not supported upon stalks, and consequently no brood-chamber is produced.

Among the Echinoidea Desmosticha, or Sea Urchins with

ambulacra running from the mouth to the vent, which are placed centrally at the two poles of the test, Professor Wyville Thomson only cites two species, and as these belong to the family Cidaridæ, in which the development, so far as is known, always takes place without the intervention of any so-called "pluteus-stage," the chief interest attaching to these forms consists in the nursing habits of the mother. No example of this kind had previously been observed.

One of the two species in question, a true *Cidaris*, nearly allied to the common *C. papillata* of northern seas, was dredged about the middle of January at depths of from 50 to 70 fathoms in Balfour Bay, a recess near the head of Royal Sound, in Kerguelen's Land. The eggs of this Urchin, after escaping from the apertures in the genital plates at the summit of the test are passed down along the surface of the test towards the mouth, where they are received in a kind of open tent formed by the bending inwards over the mouth of the smaller, slightly spathulate primary spines which are articulated to about the first three rows of tubercles surrounding the peristome. Here the eggs are retained, and the young, which are directly developed from them, are kept under shelter until they have attained a diameter of about $\frac{1}{10}$ inch, when they are entirely covered with calcareous plates, and furnished with spines exceeding in length the diameter of the test. It is true that even before this size is reached some of them are seized with a spirit of wandering, and may be seen "straying away beyond the limits of the 'nursery,' and creeping with the aid of their first five pairs of tentacular feet, out upon the long spines of their mother," but a short excursion seems to satisfy them, and the little truants soon return to the protection of their tent. From its nursing habits Sir Wyville Thomson names this species provisionally *Cidaris nutrix.*

The other nursing Cidarid here described is a species of the genus *Goniocidaris*, which differs from *Cidaris* properly so-called chiefly by the presence of a zigzag impressed line running down the middle of each ambulacral and interambulacral area. The genus includes but few species, mostly confined to the cooler parts of the Southern Ocean, and the one now under consideration, identified by Sir Wyville Thomson with the *Goniocidaris canaliculata* of A. Agassiz, was dredged in January off Cape Pembroke, East Falkland Island, in about 10 fathoms of water. The arrangement for the protection of the eggs and young in this animal is on the same principle as in the *Cidaris* just noticed, but with this difference that the nursery is placed at the opposite pole of the test. The summit of the test exhibits a flat space, including not only the apical plates, but at least the first pair of plates belonging to each interambu-

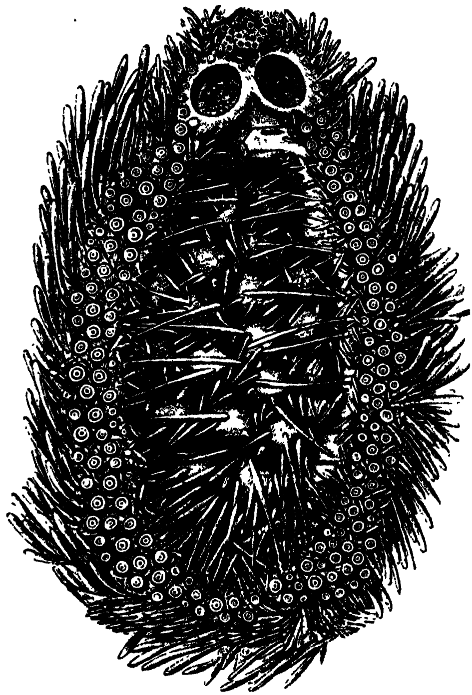
lacrum, and the primary tubercles of the latter bear two sets of spines of much larger size than are usually met with in such a position on the test of allied species, those of the outer circle being, however, considerably larger than those of the inner. These specially developed spines are cylindrical and nearly smooth, those of the rest of the surface being distinctly ribbed, and, during the breeding season at any rate, they are inclined towards the central point of the apex so as to form again a sort of open tent, into which the eggs pass directly from the minute ovarial apertures in the genital plates.

In the only example of the other section of Echinoids the Petalosticha, or forms with petaloid ambulacral areas, which is cited by Professor Thomson, the principle on which the retention and protection of the eggs and young are effected is the same as in the preceding species, but the specialisation of the apparatus is very much greater. The specimens were dredged in January from depths of from 20 to 50 fathoms in Accessible Bay, Kerguelen's Land, and the species is referred to *Hemiaster* of Desor, nearly related to the genus *Brissopsis*, which includes the well known Fiddle-Urchin (*B. lyrifera*) of the northern British seas.

In this species, which Professor Wyville Thomson describes at some length but does not name, the nurseries are four in number, and formed by a widening and depression of the paired ambulacra, which constitute four deep, thin-walled, oval cups, sinking into the cavity of the test. The ovarial apertures are as usual placed opposite the interradial areas, but by the mode of arrangement of the neighbouring spines a sort of covered passage leads from the opening into the marsupium, and along this the eggs pass. The eggs, which are very large, are arranged very regularly on the floor of the incubatory pouch, and each egg is held in its place by two or three short spines which bend over it (fig. 4). The occurrence of numerous specimens of this Urchin, with eggs and young in all stages, facilitated the investigation of the process of development, and proved that this is effected directly. The eggs, when first placed in the pouches, are of a deep orange colour and enclosed within a soft vitelline membrane which they entirely fill. As the blastoderm is formed they become paler, increase in size probably by the imbibition of water, and soon exhibit a whitish spot with a slightly raised border indicating an opening which is presumably the permanent mouth. The surface then acquires a translucent appearance, and becomes strongly tinged with dark purple and greenish pigment, when "almost immediately, and without any definite intermediate steps, the outer wall is filled with calcified tissue, it becomes covered with fine spines and pedicellariæ, a row of tentacular feet come into action round the mouth, the

vent appears at the posterior extremity of the body, and the young assumes nearly the form of the adult." By this time the young animals having acquired a considerable increase of size, their nursery apparently becomes rather small for them and they begin to jostle each other on the floor of the breeding-pouch, and very soon to push each other out between the spines which fringe the pouch. At this period the test of the young Urchin is about $\frac{1}{10}$ inch long, but its intestine is found to be

FIG. 4.



Hemiaster, sp. Arrangement of the eggs in one of the marsupial cavities. (Five times the natural size.)

already full of dark sand and to follow nearly the same course that is characteristic of the adult.

In the Asteridea, or true starfishes, an example of the marsupial development of the young has already been recorded by Sars in the case of *Pteraster militaris*, a northern species, in which this process takes place in a brood-chamber formed very much in the same fashion as in the *Psolus* already described, by the stalked paxilli, or calcareous plates of the dorsal surface. Professor Wyville Thomson describes a similar example in a species of *Archaster*, named by him provisionally *A. excavatus*, and allied

to the northern *A. Andromeda*, which was dredged in January from a depth of thirty fathoms off Cape Maclear on the south-east coast of Kerguelen's Land. It is rather a large starfish, attaining a diameter of four or five inches from tip to tip of the arms, and the whole dorsal surface is covered with a pavement-like mosaic of irregularly hexagonal plates. These plates, however, are not directly imbedded in the skin, but supported upon rather slender shafts, so that the whole space covered in by them forms a great series of columned arcades. From the ovarial openings the eggs, when mature, escape into these arcades, and they may be seen in great numbers in the spaces between the shafts of the paxilli, when the arms are bent so as to separate the hexagonal plates of the surface. The discharge of eggs into the brood-chamber appears to be continued for some considerable time, and thus eggs and young in different stages of development are to be found together in the spaces. In the young no traces of the formation of a locomotive pseudembryo could be detected, but it is possible that, as in *Pteraster militaris*, in which the process of development is very similar, some provisional organs may exist at an early period.

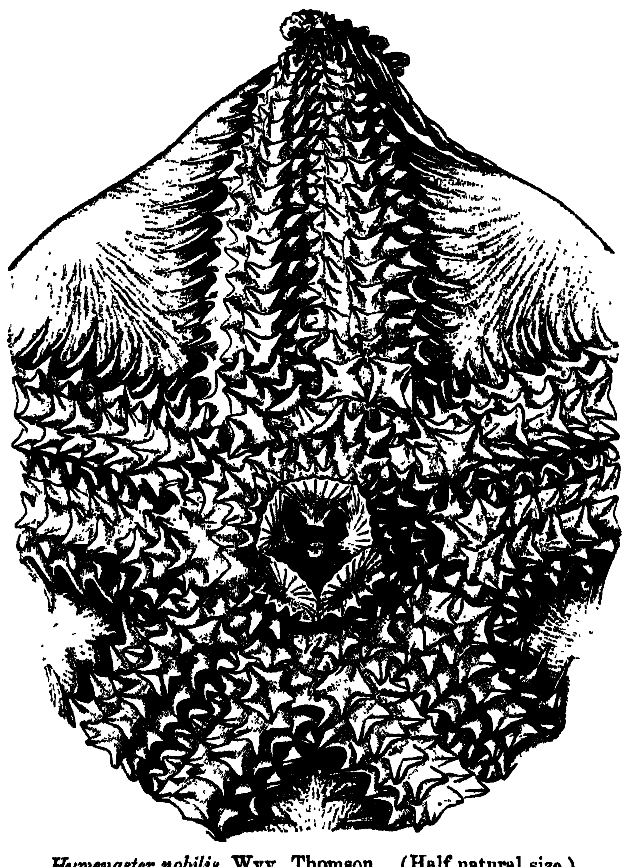
The young animals remain in the brood-chamber until at least six ambulacral suckers are formed on each arm, but when they have attained this degree of maturity they make their way out into the world by pushing through between the hexagonal surface-plates of the paxilli. The first part of the young animal that makes its appearance is always the oral surface, in general the very centre of the body with the mouth; the arms are gradually disengaged afterwards. The young generally make their escape from the nursery between the plates near the re-entering angles between the arms; there they remain for some time clustered, adhering to the surface of their parent in some mysterious manner by the centre of the dorsal surface. Sir Wyville Thomson was unable to ascertain by what means this adhesion is effected, but he says that the attachment is very slight, and that the young animals are removed by the least touch. They remain adherent, however, until they have acquired about twenty tentacular feet in each arm, when they cast themselves upon the world to shift for themselves. It is curious that in the young the madreporiform tubercle exists near the margin of the disc between two of the arms, whilst in the adult it appears to have sunk down beneath the stalked paxilli, and is completely concealed.

Another nursing starfish belongs to the genus *Hymenaster*, established by Professor Thomson some years ago ("Depths of the Sea," p. 120) for a small starfish dredged off the north of Scotland in 500 fathoms of water. The dredging operations of the *Challenger* have shown that this genus is very widely dis-

tributed in the deep waters, its representatives having been met with in all parts of the ocean at depths varying from 400 to 2500 fathoms. The species here described under the name of *Hymenaster nobilis*, was obtained from a depth of 1,800 fathoms, with a bottom of *Globigerina*-ooze at a station 1,099 miles south-west of Cape Otway, in lat. 50° 1′ S., and long. 123° 4′ E. The bottom temperature was only 0.3° C. (=32·4° F).

Hymenaster nobilis is a large species, measuring about a foot in diameter from tip to tip of the arms, the spaces between

Fig. 5.

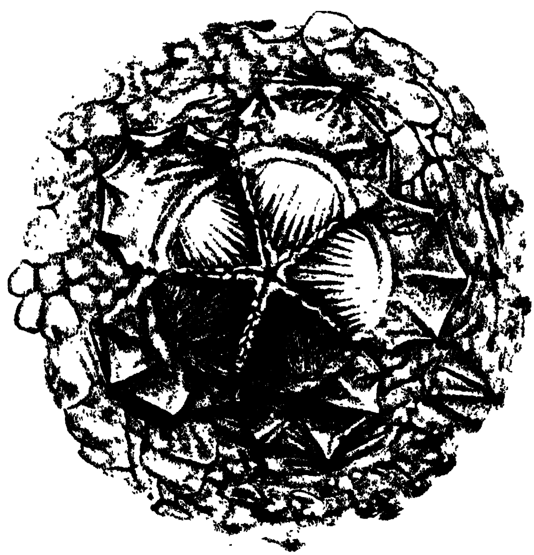


Hymenaster nobilis, Wyv. Thomson. (Half natural size.)

which are entirely filled up by fleshy webs, so that the general form of the body becomes a regular pentagon, very much as in the genus *Pteraster*, to which *Hymenaster* is nearly allied. The whole upper surface of the body and arms is covered with

bundles of from four to six diverging spines about one-eighth of an inch in length, and these support and stretch a strong membrane quite free from the surface of the perisome, having an open space beneath it, like the canvas of a marquee. At the centre of the dorsal surface this membrane terminates at a large aperture, about three-fifths of an inch in diameter, surrounded by a beautiful valvular apparatus which may be best described in Sir Wyville Thomson's own words. He says, "These valves do not essentially differ from the ordinary radiating supports of the marsupial tent; a stout calcareous rod arises from the end of the double chain of ossicles which form the floor of the ambulacral groove. From the outer aspect of this support three or four spines diverge in the ordinary way under the tent-cover; but from its inner aspect six or eight slender spines rise in one plane with a special membrane stretched

FIG. 6.



Hymenaster nobilis, Wyv. Thomson. The marsupial chamber with the valves closed. (Twice the natural size.)

between them. When the valves are raised and the pentagonal chamber beneath them open, these spines separate from one another, and, like the ribs of a fan, spread out the membrane in a crescentic form (fig. 5); and when the valves close, the spines approximate and are drawn downwards, the five valves forming together a very regular, low, five-sided pyramid (fig. 6). Looking down into the chamber when the valves are raised, the

vent is seen on a small projecting papilla in the centre of the floor, and between the supporting ossicles of the valves five dark open arches lead into the spaces opposite the re-entering angles of the arms, which receive the ducts of the ovaries." Although there is no doubt that this remarkable apparatus is destined for the reception of the eggs and the protection of the young during their development, the eggs having been found beneath the membrane in the angles of the arms, and, in a more advanced stage, under the central tent, the phenomena of development could not be studied, such delicate objects being always more or less destroyed when brought up from such great depths as that at which the *Hymenaster* was dredged.

The last species noticed by Sir Wyville Thomson is a brittle star, or Ophiurid, named by him *Ophiocoma didelphys.* It was obtained in January, 1874, at the entrance to Royal Sound and in several of the fjords and bays of Kerguelen's Land. The species is particularly remarkable for the number of its arms, which is normally seven, instead of five, and varies from six to nine.

Most of the adult females of this *Ophiocoma* were found to have groups of young clinging to the upper surface of the disc, the largest being about one-fourth the size of the mother, and the others diminishing in size until the smallest were less than one-sixteenth of an inch across the disc. The largest of the young starfish were always uppermost, and their size decreased downwards, their starting point being the genital clefts on the lower surface of the mother's body. The earlier stages appear to be passed through in the interbrachial parts of the body-cavity, in which, in many specimens, groups of eggs and of young in course of development were found. The examination of these proved that in this species the development of the young from the egg is perfectly direct,—no provisional mouth and no pseudembryonic appendages are found, and the primary aperture of the gastrula persists as the mouth and excretory orifice of the mature form.

Although, as has already been stated, the production of a Pluteus or other pseudembryonic form, or of larvæ with provisional appendages to be afterwards cast off, as a first stage of development is by no means universal among the Echinodermata, it is at least so general as to render the occurrence of these numerous instances of probably direct development in southern forms of the sub-kingdom extremely interesting. And it acquires a special interest from its being coupled with the possession by the adult of special arrangements (brood-cavities and nurseries) for the protection of the young. Of course, although the term "marsupium" has been applied by Sars and other writers to the brood-cavity in which the young Echinoderms are reared, the analogy with the true marsupial pouch of the lower

Mammalia is confined to the protection it affords to the young, which are, as Professor Wyville Thomson says, merely retained in a kind of commensal connexion with the parents until they are in a condition to shift for themselves; the young animals do not appear to be nourished directly from the parent.

As to the reason for the prevalence of such a mode of reproduction among the Echinodermata of the southern seas, often in species whose near allies in other seas show a totally different series of phenomena, it is exceedingly difficult to form even a probable conjecture. The arrangements are evidently protective, but against what? From the remarks made by Sir C. Wyville Thomson he would appear inclined to consider the phenomena to have their *raison d'être* in climatal causes, and yet he says that he is not "in a position to affirm that in these high southern latitudes direct development is universal in the sub-kingdom," and he adds, "I believe, indeed, that it is not so; for species of the genera *Echinus*, *Strongylocentrotus*, and *Amblypneustes* run far south, and a marsupial arrangement seems improbable in any of these." Nevertheless, it is a remarkable fact that during the southern cruise of the *Challenger* between the Cape of Good Hope and Australia only a single form of Echinoderm "pseudembryo" was taken in the towing net, and that was supposed to be the larva of a *Chirodota* from the presence of calcareous wheel-like bodies in its skin.

THE ARCTIC EXPEDITION.

By E. G. RAVENSTEIN, F.R.G.S.

AFTER the return of Sir Edward Belcher's expedition in 1854 the Government of this country appeared to have given up all idea of further prosecuting Arctic discoveries. Other nations, in the meantime, had successfully entered upon this field of research. Swedes and Norwegians enlarged our knowledge of Spitzbergen and of the seas washing the coasts of Novaya Zemlya; Americans pushed their way up Smith Sound as far as the shores of the Polar Sea; the Germans directed their principal efforts to the eastern coast of Greenland, whilst an Austrian expedition attempted the north-west passage, and, failing in its object, discovered an Arctic archipelago to the east of Spitzbergen. All these expeditions were the result of private enterprize, and the successes they achieved were calculated to rouse the emulation of England, which for many years had taken the lead not only in Arctic exploration but also in maritime researches of every kind. Amongst those who most persistently advocated the renewal of Arctic research the late Sherard Osborn holds the foremost place. For ten years he agitated this question, until at length he succeeded in prevailing upon Government to fit out another expedition. During all these years the selection of the most practicable route had formed a fertile source of discussion, but the advocates of that through Smith Sound prevailed in the end, and the leader of the expedition was instructed to take his vessels to an advanced position beyond that Sound, and then to explore the neighbouring coasts, and, above all, to make an effort to reach the North Pole.

Smith Sound had already been the scene of important Arctic enterprizes. Bylot and Baffin, its discoverers, had reached Whale Sound in lat. 77° 30′ N. Captain Inglefield, in 1852 sailed up it to lat. 78° 28′ N. and reported the existence of open water, which he thought might extend as far as Bering Strait and the coasts of Siberia. But Dr. Kane, who hoped to profit by this discovery, barely succeeded in reaching Rensselaer Harbour, where his vessel was frozen in, and whence he effected his retreat,

in boats, to the Danish settlements in the south. Mr. Morton, however, one of his companions, had proceeded with a sledge as far as Cape Constitution, in lat. 80° 35′, and he too reported the existence of open water, and thus incited to further research. The work was taken up by Dr. Hayes, but after a severe struggle against the ice that explorer only reached Port Foulke at the entrance to Smith Sound (lat. 78° 17′), where he wintered. He then proceeded with a dog sledge over the Polar Pack, and travelling at a rate of only two miles a day, reached Cape Lieber in 81° 27′ N., and again reported open water to the north. Far more successful than either of these expeditions was that conducted by Captain Hall, who, between August 23, and Sept. 3, 1871, sailed from lat. 73° 20′ N. to 82° 11′ N., outside Robeson Channel, without being seriously interfered with by ice, but was there stopped by the impenetrable Polar Pack. He wintered in Thank God Harbour, in lat. 81° 38′ N. The subsequent fate of this expedition is well known. Its leader lies buried in Arctic soil; his vessel was beset by the ice, drifted helplessly down Smith Sound, and was finally lost; a portion of its crew passed a second winter in Lifeboat Cove, whilst the remainder drifted southward on a floe of ice until picked up by a passing whaler.

Such were the antecedents of the Smith Sound route when a fresh effort to reach an open Polar Sea by means of it was determined upon. Hall's unique feat of taking his small steamer to a latitude never before attained in any part of the Arctic regions in some measure justified the opinion that a steamer of greater power, even if less favoured by the season, might repeat and even surpass his achievement.

On a bright afternoon in May, 1875, the *Alert* and *Discovery*, the two vessels fitted out for this service, sailed out of Portsmouth Harbour, strengthened to battle with the ice, and liberally provisioned for three years. Having taken on board forty-four Greenland dogs, at Godhavn and Ritenbenk, they parted from their tender, the *Valorous*, on July 17, and stood boldly across Baffin Bay, passing through the dreaded 'Middle Pack' in the unprecedentedly short space of thirty-four hours. On July 28, they were already at Port Foulke, with the entrance of Smith Sound perfectly clear of ice and none floating past to the southward, though the wind, at the time, was blowing fresh from the north. Lifeboat Cove, the scene of the shipwreck of Hall's ill-fated *Polaris* was visited, and the two vessels then crossed to the western shore of Smith Sound. On July 29, when about half-way between capes Isabella and Sabine, the first ice was sighted, and thenceforth the advance to the north proved a constant struggle. Advantage was taken of every opening in

the ice; ramming and blasting were resorted to; and only by audacity, guided by discretion, was it possible slowly to advance. The floes at first were only four feet in thickness, but beyond Cape Frazer old hummocky pieces, twenty feet and more in thickness, had to be encountered. At length, after twenty-five days of this ice navigation, a well-sheltered harbour at the entrance of Lady Franklin Sound was reached, and at once fixed upon as the winter-quarters of the *Discovery*. This was on August 25. Two days afterwards the vessels parted company, and Captain Nares, carefully availing himself of every opportunity that offered, worked his way through the pack. By noon on September 1, he reached 82° 24′ N., the highest latitude ever attained in a vessel, and finally found himself closed in for the winter, on an open coast, in lat. 82° 27′, protected to the seaward by a powerful barrier of gigantic floe-bergs, eighty feet in thickness, aground in twelve fathoms of water.

The autumn sledge-travelling was begun on September 9th, and on the 27th of that month Lieut. Aldrich reached 82° 48′, the highest latitude hitherto attained, and ascending a mountain 2,000 feet in height, was not able to discover land to the north. The sun disappeared on October 12th, only to reappear on March 1st. The winter passed cheerfully, and on the approach of spring officers as well as men were apparently in the finest condition for undergoing the hardships of sledge-travelling. The 3rd of April was fixed upon for the departure of the *Alert's* travelling parties, and on the morning of that day seven sledges with fifty-three officers and men started for the north. On reaching the vicinity of Cape Joseph Henry the sledges separated, some returning to the ship, others proceeding to the north or west. Captain Markham had command of the northern division, whose task it was to proceed over the ice due north in the direction of the Pole. Captain Nares certainly did not expect that this journey would prove a success, as far as reaching a high latitude was concerned, but an effort had to be made. It was by no means certain that the ice, at some distance from the land, would not be found to be in motion, and hence it was necessary that this party should be provided with boats, which had to be carried on the sledges. Captain Markham, with his subordinate, Lieut. Parr, started on the 11th, and in spite of the ruggedness of the ice which necessitated clearing the road with picks and shovels, the intense cold, and the visitation of scurvy, they and their men struggled on until May 12th, when they planted their flags in lat. 83° 20′ 26″, the highest latitude ever attained by this or any other expedition. The progress made good daily only averaged 1¼ mile, and never exceeded 2¾ miles, and when the party again reached the land, on June 5, only the two officers and six men were able to drag the sledges. It was then Lieut.

Parr started upon his memorable thirty miles march through the snow and returned with the succour so urgently needed, alas! too late to save the life of one of these fearfully tried men.

Meanwhile Lieutenants Aldrich and Giffard had gone west, and on May 17th the former of these officers having traced the coast for 220 miles, reached his furthest in lat. 82° 16′ N., long. 85° 33′ W. His return journey proved a severe struggle, and he reached the ship on June 26th, having been away eighty-four days, during which he travelled 620 miles.

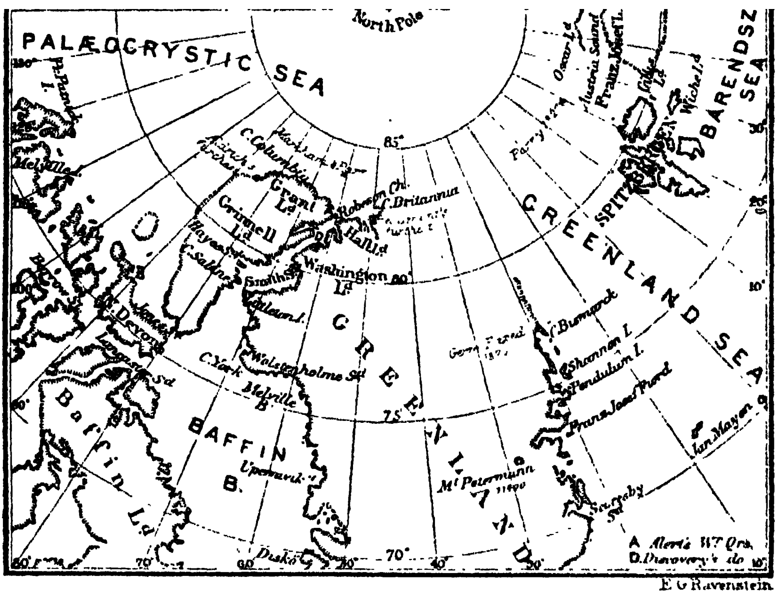
Upon Lieutenant Beaumont, Dr. Coppinger, and Lieutenant Rawson, of the *Discovery*, devolved the task of exploring the coast of Greenland. Their struggles proved equally severe with those of the other parties. On May 21st, Lieutenant Beaumont reached his furthest in lat. 82° 18′ N., long. 50° 40′ W., and saw land far in the north, under lat. 82° 54′. Two men of this eastern division fell victims to scurvy and exhaustion, and its members were only again united on board the "Discovery," on August 14th, having crossed Hall Basin after the ice on both sides of it was already in motion. Lieutenant Archer, in the meanwhile, had explored Lady Franklin Sound, which he found to terminate in a narrow fiord, extending for 50 miles towards the south-west.

Captain Nares wisely determined to return home as soon as the breaking up of the ice should permit his doing so. There appeared to be no chance of taking the ships further north, and at best he would merely be able to extend the exploration of the coasts for an inconsiderable distance, particularly as the health of officers and men had suffered severely. On July 20th, a decided movement of the ice took place; on the 23rd, a strong south-westerly wind drove the pack away from the shore, and on the 31st, having cleared a passage through the protecting barrier of floe-bergs, they entered Robeson Channel. After narrowly escaping destruction from ice pressing upon the ship, she joined the *Discovery* on August 11th. Taking advantage of every opening in the ice, the two ships worked their way slowly towards the south. Cape Frazer was passed on August 25th; open water reached on September 10th, when off Cape Victoria, and it was then possible to make a clear run for Cape Sabine. Captain Nares thus sums up the chances of navigating Smith Sound:—"To the latitude of Polaris or Discovery Bay, if no accident happens to the ship, the passage may probably be made with perseverance most years, by starting early in the season; but it will at all times be a most dangerous one." No vessel, he is confident, will ever round Cape Joseph Henry, or pass beyond Cape Brevoort in navigable water.

The geographical results of this expedition, as far as they find

a place upon our maps, may not, perhaps, realize the expectations of some of the more sanguine advocates of the Smith Sound route, but they are nevertheless of great importance. Not only have the officers of the expedition more carefully delineated some of the discoveries of their predecessors, but they have also laid down about 300 miles of coast which hitherto had not figured upon our maps.

But of far greater importance is their determination of the nature of the Polar Ocean, such as it exists to the north of Smith Sound. The notion of a navigable sea in that portion of the Polar basin has been exploded, and the impracticability of reaching the North Pole by travelling with sledges over the ice



E. G. Ravenstein.

has most conclusively been demonstrated. The sea of which Robeson Channel is one of the most important outlets is evidently of vast extent, and there can be no doubt of its communicating through Bering Strait with the Pacific Ocean. Dr. Bessels, the scientific member of Hall's expedition, already ascertained that the Pacific tidal wave enters Robeson Channel from the north, and meets the Atlantic tide in the vicinity of Cape Frazer. Sir George Nares confirms this fact. Moreover, the driftwood collected by Hall in Polaris Bay has been determined to be of American and Pacific origin, and evidently reached the locality where it was picked up by means of a current passing through Bering Strait, and along the eastern coast of Wrangel Land. This applies more particularly to a

piece of walnut, supposed to have been derived from Japan or the eastern coast of Asia. The valuable collection of driftwood made by members of the late expedition, in all the bays to the north of Robeson Channel opening towards the west, has not yet been examined by a scientific man, but we do not doubt for a moment that it likewise will turn out to be traceable to the north coast of America and to the Pacific, and not to the coast of Siberia. The current which carries driftwood will also carry ice-floes, and thus ocean-currents, the set of the tides, and the predominating westerly and north-westerly winds, noticed by Hall as well as by Sir G. Nares, all combine in accumulating vast masses of ice within the western half of the sea extending from Bering Strait to Robeson Channel, and now appropriately named the "Palæocrystic Sea," or sea of ancient ice. The ice met with to the north of Robeson Channel is evidently as formidable as that known to exist on the western coast of Banks' Land and Prince Patrick Island. Captain Nares describes these ancient floes as being 80 feet in thickness and 1 to 4 miles in diameter. Few, even of the initiated, we are told, can distinguish these floes from icebergs, which they rival and sometimes exceed in size. Where they float into shallow water, they ground in 8 to 12 fathoms, forming a fringe of detached masses of ice rising from 20 to upwards of 60 feet above the sea-level, and affording protection to a vessel between them and the land. But where the coast is steep, they extend close to the beach-line, and if the pressure is strong, as to the east of Robeson Channel, near Cape Stanton, these huge masses are piled up into chaotic confusion. Captain Markham, who travelled over ice of this description, when making his effort to attain a high latitude, tells us that he met only rarely with large floes, having smooth surfaces. As a rule the heavy floes were of moderate size, their surface being uneven and covered with ice-humps, 10 to 20 feet in height, and their edges fringed by hummocks formed from fragments of the previous summer's pack-ice, frozen into a rugged chaotic mass of angular blocks, 40 to 50 feet in height. The snow which covered these floes was scored in ridges, running east and west, in accordance with the prevailing winds, or was heaped up along the foot of the hummocks in deep drifts. The floes were frequently separated by fissures, covered by ice of one year's growth, their general level being about 6 feet above this. On advancing towards the north, the hummocks became larger, and the snow-drifts deeper, until, at the furthest point reached, a perfect labyrinth of squeezed-up hummocks had to be faced.

In the beginning or middle of July the whole pack of ice begins to drive backwards and forwards according to the winds and currents, its main course being towards Robeson Channel, through which it escapes from the polar basin. As the season

advances the pack gradually breaks up into contending masses, small pools of water appearing occasionally. In September the frost sets in again, cementing the broken masses of ice, and by the end of October or beginning of November the pack, which till then had been drifting up and down the channel, begins to settle itself for the winter. No movement whatever has been observed during that season, occasional cracks, caused by tidal currents, alone excepted. A certain qnantity of this ice certainly escapes through Robeson Channel into Smith Sound and Baffin Bay, but compared with the vast extent of the Palæocrystic Sea this quantity is but small, and the evacuation is more than compensated for by the constant western drift of the ice due to winds and currents. The sea to the north of Robeson Channel indeed appears to be hopelessly ice-bound, and the only chance of penetrating the Palæocrystic Sea would appear to be offered by pushing northward along the unexplored coast of Wrangel Land.

Captain Sir G. Nares is of opinion that the Greenland coast does not extend much further north than 82° 55′, and that a portion of the ice of his Palæocrystic Sea finds an outlet to the north of that island and drifts southward along its eastern coast. We would observe, however, that driftwood of Pacific or American origin might be expected to be drifted upon the eastern coast of Greenland if such were the case. The driftwood collected by the German expedition contained Siberian species only, such as are found on the northern and eastern coasts of Spitzbergen, and this proves conclusively that the cold Arctic current passing along that coast carries away the ice formed in the Asiatic half of the Polar basin, and not that formed in the western, American half. Thus much appears to be certain that there are no glaciers in Northern Greenland, or to the north of it, for no icebergs were observed by Sir George Nares. This absence of glaciers is due to the small quantity of snow which falls in these high latitudes, and in their absence the musk ox, lemming, and other animals could easily have migrated from Grinnell Land by a northern road to Eastern Greenland, as suggested by Dr. Brown in an able article published in the "Arctic Papers of the Royal Geographical Society," even if that island should be found to extend far beyond 83° N. Dr. Petermann has hazarded an opinion that the American and Asiatic halves of the Polar basin are separated by land or a chain of islands, extending from Greenland to Wrangel Land. The late Admiral Sherard Osborn likewise assumed the sea, now named the Palæocrystic, to be land-locked, and this theory we believe to be most in accordance with the physical geography of the Arctic regions, as far as it is known to us.

The strictly scientific work of the expedition has not been neglected, for, although the scientific staff was but small, most of the officers had been trained as scientific observers, and they all contributed to the utmost of their power towards enriching the scientific collections. Dr. Coppinger devoted his attention to geology; Captain Feilden, Mr. Chichester Hart, and the Rev. Mr. Pullen studied the natural history of the regions visited; Lieut. Aldrich and Dr. B. Ninnie had charge of the meteorological observations; Captain Markham and Lieuts. Archer, Giffard, and Fulford made magnetic observations; Lieuts. Parr, Conybeare, and May observed with the spectroscope; Lieut. Aldrich with the polariscope; Dr. Moss worked with the microscope; Dr. Colan was engaged in ozone testing and other delicate researches; Lieuts. Beaumont and Rawson made pendulum observations: and Lieuts. Parr and May had charge of the transit instrument. This enumeration of scientific work performed promises a rich harvest of results whenever the numerous observations of these officers shall have been properly worked out. As respects the geological features of the countries explored it was found that Silurian limestones, abounding in fossils, are the most characteristic formation along Smith Sound. Miocene beds, including a thick seam of coal, were found as far north as 81° 44′ N. The greatest cold observed at the *Alert's* winter-quarters was −73·7° F.; the minimum temperature for twenty-four hours was −70·31° F.; and for thirteen consecutive days the thermometer did not rise above −58·9° F. These temperatures appear to be far more severe than those observed by Dr. Bessels in Polaris Bay, where the minimum in January, 1871, only amounted to −58° F. At Wolstenholme Sound, near the southern entrance of Smith Sound, in lat. 76° 30′ N., a minimum of −69·5° F. has been registered, whilst at Yakutsk the thermometer has actually been known to fall to −76° F.

Westerly and north-westerly winds predominated apparently throughout the year. In autumn there was a heavy fall of snow, but only about six to eight inches fell in the course of winter, and the hill-tops were uncovered by the winds, and remained so until May and the early part of June, when there was another heavy fall. Auroras were observed frequently, but none of the flashes were brilliant, and no connexion between them and magnetic or electric disturbances has been established. Animal life was more abundant and vegetation more luxuriant in the winter-quarters of the *Discovery* than in those of the *Alert*. Musk-oxen, wolves, polar hares, Arctic foxes, and lemmings were found to extend as far as the polar basin. A few ducks, geese, and ptarmigans were shot, but the birds, we are told, do not migrate towards the north or north-west, and it is concluded from this that the ice-bound sea is of considerable idth in these directions.

There can be no doubt that the results of the expedition, as far as we are able to judge from preliminary accounts, must prove highly satisfactory to the geographical world. It is more especially matter for congratulation that the scientific work has not been neglected. A higher latitude might no doubt have been reached had a coast extending northward in the direction of the Pole been discovered, but the attainment of a high latitude should at all times be subordinated to a thorough examination of the land and sea forming the object of exploration.

We do not believe for a moment that England will be content to rest upon the laurels won through this expedition. The Smith Sound route has now been fairly tried, and has been found to be impracticable as one of the gateways leading into the polar basin. There are, however, several other routes offering chances of success, and not one of these has been attempted hitherto by powerful steamers, expressly built for ice-navigation, and manned by a thoroughly competent set of men. One of these routes leads through Bering Strait and along the eastern coast of Wrangel Land into the Palæocrystic Sea. Then there is the route between Spitzbergen and Novaya Zemlya. The *Tegetthoff* was beset there by the ice and drifted about at the mercy of winds and currents until stranded upon the inhospitable shore of Franz Joseph Land, but Norwegian fishermen have frequently passed along it to the eastern extremity of Novaya Zemlya, and Professor Nordenskiöld, than whom none has more experience of these seas, proposes to give it a fair trial next year. A third route, due north from Spitzbergen, enables a vessel to attain a latitude of 81° 30′ or 82° N. almost every year, and, once successful in crossing the ice-stream setting in the direction of Greenland, there opens a fair prospect of making important discoveries. And lastly, there is the route along the east coast of Greenland, whose most persistent advocate is Dr. Petermann. In a letter recently addressed by that geographer to the President of the Royal Geographical Society he points out that the two German expeditions directed to that coast were not equipped as well as a government expedition would have been, and that their comparative want of success need not therefore cause surprise. A well-proved steamer might succeed where the schooner and the little steamer of the Germans were forced to turn back, and Captain Gray, who is thoroughly acquainted with the Greenland sea, feels certain that, once across the ice-stream, open water and undiscovered Arctic islands might be reached. An expedition, such as that of Captain Nares, if it once succeeded in establishing itself on the coast of Greenland, say in 80° N., might really do good work, though Dr. Petermann is oversanguine when he

holds out a hope of "finishing the North Pole in a season," or of "steaming away to the Pole."

Already we hear that in Sweden and the Netherlands they are preparing for an Arctic campaign. Dr. Petermann, too, is again active on behalf of a German venture; the Americans are anxious to "verify" the discoveries of Captain Nares. Is England, not to speak of other maritime countries, to look on, an idle spectator? Might she not, through her example and influence, induce the nations of the world to act on a preconcerted plan in carrying on these Arctic explorations? Five or six expeditions, attacking the North Pole from different directions, and in the same season, stand a better chance of success than the irregular expeditions which have been sent forth hitherto. Their results, too, would prove more useful, and the objects which Lieut. Weyprecht had in view when he proposed to establish physical observatories within the Arctic Circle could partly be attained by them. Will England prove her maritime superiority by taking the lead in this work of Arctic exploration?

REVIEWS.

OSTRICHES.*

VERY considerable interest attaches to the Struthious order of Birds, both from a scientific and an economical point of view. Their remarkable characters, separating them as a group distinct from and morphologically equivalent to all the other existing birds; their curious relations to other classes of vertebrate animals; their singular geographical distribution, and the relations of the living to extinct forms give them great importance in the eyes of the zoologist, whilst the beauty of the plumes produced by at least one of the species, cannot but render it interesting to the fair wearers of such ornaments. The Roman ladies, as we learn from this book, did not adorn themselves with ostrich feathers, which were used, on the contrary, for the decoration of their helmets by a class of men generally supposed to need no such extraneous aids for the captivation of female hearts; but in our days, and in civilized countries, the ladies are generally allowed to have a monopoly of ostrich plumes. That they do their duty pretty thoroughly in the consumption of these articles of luxury is sufficiently clear from the tabular statements here given by M. de Mosenthal, from which it appears that the annual exportation of ostrich feathers from Africa, at present amounts in value to about 603,000*l.*, which probably represents a weight of 120,000 lbs., each pound containing at least 120 feathers.

It may easily be conceived that such a consumption as this gives rise to very considerable slaughter of the birds, and it has long been felt that if the demand for ostrich-feathers should continue to increase as it has done for some years, there will be great difficulty in obtaining an adequate supply. As early as 1859 the Acclimatization Society of Paris, taking these facts into consideration, offered prizes for the successful domestication of the African ostrich in Algeria and Senegal, and in consequence of the attention thus attracted to the matter, several successful attempts have been made both in Africa and in Europe to bring up and breed the ostrich in captivity. But even at a much earlier period it appears to have been the custom among certain native African tribes to keep tame ostriches in enclosures, in order to obtain their feathers easily; and at the Cape a hundred years ago, according

* "Ostriches and Ostrich Farming." By Jules de Mosenthal and James Edmund Harting, F.L.S., F.Z.S. With Illustrations. London: Trübner & Co. 1876.

to Sparmann, many of the farmers "had a number of tame ostriches on their farms, which were allowed to feed at large, and which supplied their owners with plumes, which were made into brooms and helped to drive away the mosquitoes." These early attempts at the domestication of the ostrich were comparatively insignificant. The supply of feathers was chiefly obtained from the wild birds, and, in consequence of their increasing scarcity in easily accessible localities, the price of the commodity became very high. Towards the year 1870, however, the attention of South African farmers was directed to the advantages of keeping ostriches as domestic birds; and it is to the increasing adoption of this practice that we must ascribe the enormous increase that has taken place since 1870 in the quantity of feathers exported from that part of the world. In 1865, it appears there were only 80 tame birds in the Cape Colony, whilst in 1875 the census returns showed the existence of no fewer than 32,247. The feathers obtained from the tame birds are stiffer and less valuable than "wild feathers," but nevertheless this new industry must be a most productive one, if we may judge from the experience of Mr. W. Kinnear, of Beaufort West, who in 1870 had twenty-nine ostriches on eight acres of garden-ground, fourteen being in immature plumage. "For three pluckings of fifteen of them, at intervals of eight months, he received the sum of 240*l.*, which is at the rate of 120*l.* a year, or 8*l.* per bird." It must be remarked that in 1870 the price of the feathers was unusually low, and that the space occupied by these twenty-nine birds was estimated to be sufficient for three times the number.

We have devoted so much space to the commercial side of the subject partly because it may interest many of our readers to know the extent and importance of the trade in ostrich feathers, but mainly because it is to the curiosity excited by the display of a large collection of feathers at the Vienna Exhibition of 1873 that we are indebted for the admirable work on the Ostriches by MM. de Mosenthal and Harting. The practical part of the subject is treated by the former gentleman, who describes the earlier attempts at the domestication of the ostrich, notices the endeavours that have been made to introduce ostrich-farming into other colonies, especially in Australia; gives full details as to the progress of the industry in Africa, where it has even advanced so far as the adoption of incubators, and "artificial mothers" for hatching and rearing the young; and furnishes most interesting particulars connected with the trade in ostrich feathers. As a contribution to economical zoology, Mr. de Mosenthal's share of this book is most interesting and valuable.

We think it was Sir Richard Steele who, in speaking of his starting the "Spectator," and calling in the assistance of his friend Addison, described himself as being in the position of some small prince who had been aided by a big one, and found himself in the end of little consideration by the side of his ally. We fancy that Mr. de Mosenthal might say something of the same kind. Reading between the lines of the preface, it seems pretty clear that that gentleman, who, as Commissioner for the South African Colonies, exhibited the collection of ostrich-feathers at Vienna, having determined on publishing a short account of the new industry, thought it desirable to prefix to his treatise an account of the natural history of the ostrich, and

called in to his aid the genial pen of Mr. J. E. Harting, whose varied powers and great ornithological knowledge eminently fitted him for the task; and that the few introductory notes on the natural history of the ostrich have grown into a sort of monograph of all the species of Struthious birds, occupying just three-fourths of the book, which, as the authors tell us, has grown by a "process of evolution from a pamphlet into a volume." We fancy that few who are interested in natural history studies will be inclined to quarrel with the authors on this account. It is no small advantage to have a good, readable, and reliable natural history of so interesting a group as the Struthious birds, and this is what Mr. Harting has presented to us. He describes all the species of the group—the African Ostrich, the South American Rheas, the Emus of Australia, and the Cassowaries of Australia and the islands of the Australian region; and gives a short account of the curious Kiwis (*Apteryx*) of New Zealand, which are also referred to the Ratitæ. The natural history of each species is given so far as it is known; and in search of information on this subject, the works of a great number of naturalists and travellers have been ransacked, with the most interesting results. In connection with this, however, we cannot but think that the long extract from M. Vavaseur's account of the Rhea ought hardly to have been given in its original French. The little volume is illustrated with good woodcuts of some of the species described, and of the characteristic parts of others, and a few hunting scenes are introduced.

NORTH AMERICAN MOTHS.*

THE American Geological Surveys by no means confine their activity to what might seem at the first glance to be their legitimate sphere. The actual officers of the survey are expected to have an eye for the picturesque in the scenery of the out-of-the-way places that their labours necessarily lead them to visit, and to notice any facts of interest in other departments of science than their own, and in general naturalists are attached to the parties sent out, in addition to the regular staff of the survey, for the purpose of investigating the zoology and botany of the regions traversed. In this way a great amount of information upon the general natural history of the vast territories of the United States is rapidly being accumulated, and the authorities publish the results of the investigations thus made in by no means a niggardly fashion. Several of the States have already published valuable treatises on the zoology of their districts, and in addition to many papers of interest on zoological subjects which have appeared in its bulletin, the Geological Survey of the Territories some years since published a monograph of the Acrididæ of the United States by Mr. Cyrus Thomas. Entomologists are now indebted to Dr. Hayden for another valuable work on insects in the "Monograph of the Phalænid Moths" of the United States

* "Report of the United States Geological Survey of the Territories," Vol. X. "A Monograph of the Geometrid Moths or Phalænidæ of the United States." By A. S. Packard, Jun., M.D. Washington. 1876.

by Dr. Packard which has recently appeared. It is a most important contribution to entomological literature and at the same time is precisely one of those works which could never have been so well produced by private enterprise.

The geometrid moths, the *phalænæ geometræ* of Linnæus, have received their name, as is well known to entomologists, from the peculiar mode of progression of their caterpillars, which is a necessary consequence of their usual conformation. These curious larvæ generally have only two pairs of fleshy prolegs situated close to the hinder extremity of the body, and in walking most of them adhere to their support alternately by these and the six true legs which are on the first three body segments, and thus move by a series of steps in which the body is alternately stretched to its full extent, and bent into a loop. Hence these larvæ are often called loopers, a name which, among collectors, is sometimes applied to the moths. Another result of the arrangement of the prolegs so far back on the body, is that many of these larvæ are able to mimic the twigs of the tree on which they feed in the most perfect manner; clinging with the hind feet they extend their bodies stiffly and thus present exactly the appearance of a bare twig.

The moths produced from these curious caterpillars are often of great beauty, although many of them display sober brown tints, more or less variegated. Others, although of sober colours, are adorned by having these arranged in most elegant patterns. But the striking species are not very numerous, and in general the Phalænidæ share the common lot of moths, in being rather difficult to determine specifically. Staudinger and Wocke's catalogue gives about 800 species of Phalænidæ as inhabitants of Europe, and although in the present work Dr. Packard does not describe half this number, those who have ever laboured at the discrimination and determination of species of moths will know that he must have undergone very considerable labour in preparing his monograph.

But whatever labour it may have cost him he may certainly congratulate himself on having produced a work which will be received with gratitude by all students of American Lepidoptera both at home and abroad. All the known species and varieties are described in detail, both the generic and specific synonymy is given in full and with dates, a most important matter in a work of this description, and all the species are figured. To make his treatise more complete, Dr. Packard has also quoted under the title "Desiderata," the original descriptions of the species which he has been unable to see, thus enabling any entomologist who may meet with one of them to determine the nature of his prize. In defining his genera Dr. Packard has availed himself largely of the characters derived from the venation of the wings, which have long been regarded as of great importance in the study of the Hymenoptera and Diptera, but have only of late years been much employed among Lepidoptera. Unfortunately the use of such characters is liable to be pushed too far, and even in the present excellent work we recognise the tendency to excessive generic division which is the great vice of systematic zoologists of the present day. However, Dr. Packard has certainly done his best to render matters as plain as possible, for he furnishes the student with six plates containing figures of the venation of the wings of all his genera. Besides, there is a plate of outlines of

various anatomical details, and six plates crowded with figures of the moths themselves, which, although not coloured are very nicely drawn and characteristic.

SCIENCE MANUALS.*

FOLLOWING the example of some other publishers Messrs. Chambers have commenced a series of "Elementary Science Manuals" intended to serve the two purposes of self-instruction and school-teaching. The manuals already published include Geology and Historical Geology, by Mr. James Gikie; Astronomy by Dr. Findlater, who is the general editor of the series; Electricity by Mr. John Cook; Chemistry by Dr. Crum Brown; Language by Dr. Findlater; and Mythology by Mr. A. S. Murray, of the British Museum. The names of these authors are of themselves a sufficient guarantee that the work is creditably done, and an inspection of the text shows that they have really succeeded in compressing into these very small volumes an astonishing amount of good and well-selected information. It seems to us, however, that some of them are rather sanguine if they expect the scholar after studying the manuals to answer some of the examination questions that they have appended to them.

PAGE'S GEOLOGICAL TEXT-BOOK.†

DR. PAGE'S "Advanced Text-Book of Geology" is so well known that we need do little more than announce the appearance of its sixth edition. Naturally there is little or no change in the general treatment of the subject, but the author appears to have carefully worked in the results of recent investigations, where these come within the scope of his work, and he has introduced a considerable amount of additional information without materially increasing the size of the book, by placing the new matter in small type. Several new illustrations have been inserted.

NORTH AMERICAN VERTEBRATA.‡

THIS little book is a synopsis of the vertebrata of the northern parts of the United States, and it ought to prove an exceedingly useful manual for residents and travellers in the region of the zoology of which it treats.

* "Chambers' Elementary Science Manuals." Edinburgh. 1875-76.

† "Advanced Text-book of Geology, Descriptive and Industrial." By David Page, LL.D., F.G.S. Sixth edition, revised and enlarged. Edinburgh and London: W. Blackwood and Sons. 1876.

‡ "Manual of the Vertebrates of the Northern United States, including the district east of the Mississippi River and north of North Carolina and Tennessee, exclusive of Marine Species." By David Starr Jordan, M.S., M.D. Chicago: Jansen, McClure and Co. 1876.

The author has evidently compiled it with great care, and the determination of the species will be immensely facilitated by the elaborate tabular arrangements which serve as a guide to the genera. The whole of these tables are to a greater or less extent artificial in their character, but they profess to be nothing more, and in some of the larger and more complex groups this very artificiality has been taken advantage of to render the tables more direct guides to the desired end than they could have been if it had been attempted to make them serve as an indication of the natural relations of the forms. Thus, when the characters of the genera are subject to some slight variation, the characters of the aberrant species are worked out separately, so that the same generic name may occur two or three times in the same table, and by this means there is no doubt the species of the genus may be got at more readily. Under the head of fishes, of course, only the forms met with in fresh water are noticed, but the reader will be astonished at the immense number and variety of the animals of this class that find a home in the great lakes and rivers of the North American Continent. The fishes, indeed, appear to be Dr. Jordan's speciality, but it is to be regretted that he has thought it necessary to adopt so many genera. Of natural history, of course, there is very little in the book, which only professes to be a synopsis. The American geographical distirbution of the species is generally given, and in some cases where an animal is common to both sides of the Atlantic, its occurrence in Europe is noted, but very frequently this piece of information is omitted even in the case of species of the same genus. This is a defect which we hope may soon be amended in a second edition.

AMERICAN GEOLOGICAL SURVEYS.*

THE energy and activity displayed by the Government geological surveyors in the United States are certainly worthy of all praise, and they are supplemented by a liberality on the part of both the central and local governments which contrasts rather strongly with what we are accustomed to nearer home. The important volumes on the "Cretaceous and Tertiary Fossil Vertebrata of the Western Territories," by Professors Leidy and Cope, and on the Cretaceous Flora of the same region, by Professor Leo Lesquereux, are now followed by a most admirable "Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country," which, while it cannot fail to interest the palæontologist by the numerous excellent descriptions and figures of fossils, and the discussion of their generic and specific relations that it contains, must prove of almost equal importance to the geologist on account of the precise definition of the divisions and subdivisions of the deposits from which the fossils described have been obtained and the light thrown on their relations to each other and to deposits in other parts of the world.

The fossils here described are the result of the collections made by the

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* "Report of the United States Geological Survey of the Territories," vol. ix. "A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country." By F. B. Meek. Washington, 1876.

officers of the survey under the direction of its chief, Dr. Hayden, who himself commenced these laborious investigations more than twenty years ago. The descriptions of cretaceous fossils alone occupy 508 pages, in which about 240 species or distinct varietal forms are described, mostly mollusca; 63 distinct forms are described from the "Brackish-water and Lignite Beds," 2 from the "Wind River Tertiary," and 7 from the "White River Tertiaries." These indications of numbers, however, give no sort of indication of the amount of valuable palæontological information contained in this volume; they represent a certain number of species of more or less interest to the student of fossils; but the remarks upon them, and especially upon the genera and their subdivisions are of the greatest importance to palæontologists everywhere.

In his "Introductory Remarks" on the geology of the locality from which his fossils were derived, Professor Meek gives elaborate comparative tables of the various sections exposed, showing the equivalence of the beds in the different localities. The lowest cretaceous deposits everywhere rest upon palæozoic and generally carboniferous rocks, and in all the sections here given are regarded as the equivalents of the Dakota group in the Nebraska section, generally containing, like the latter, numerous plant-remains. Above this group come in the Nebraska section, the Fort Benton group, and the Niobrara group, the whole attaining a thickness of about 1,400 feet in the typical locality, and forming the lower cretaceous series, equivalent to our Gray Chalk and Upper Greensand (Turonian and Cenomanian of D'Orbigny). Above these the upper series consists of two groups, the line of demarcation between which does not appear to be very strongly marked,—the Fort Pierre group with a thickness of 700 feet, and the Fox Hills group 500 feet thick. These are regarded as the equivalents of the upper chalk and Maestricht beds (Senonian, D'Orbigny). In Alabama and Mississippi, and everywhere east of the Mississippi river, the second and third, or Fort Benton and Niobrara groups appear to be absent, as also in the New Jersey section, which has served Professor Meek as a term of comparison between the American and European cretaceous series; and in New Mexico the cretaceous deposits, according to Dr. Newberry, fall into three great divisions, the lowest of which is regarded as equivalent to the Dakota group, the middle one to the two upper members of the lower series, and the uppermost to the whole of Professor Meek's upper series.

With regard to the true position of the Dakota group and its equivalents in other localities, which are so remarkable on account of the leaves of highly-organised dicotyledonous plants found in them, there seems still to be room for difference of opinion, and Professor Meek himself says, "The evidence respecting the exact part of the European cretaceous series to which the Dakota group belongs is not entirely satisfactory, the few animal remains yet known from it being mainly casts, and, so far as determined, not such forms as can be regarded as especially characteristic of any particular horizon in the cretaceous of Europe. Up to this time we also know of no single species being common to it and any of the beds alone; but then we, as yet, know comparatively only a few species of animal remains from this rock. One of these, however," he adds, "belongs to the cretaceous genus *Leptosolen*; while the other shells are allied to cretaceous species, and

unlike jurassic forms. In addition to this, the modern affinities of the numerous leaves of the higher types of dicotyledonous trees found in it, present a strong objection to the adoption of the conclusion that it may belong to a lower horizon than the Upper Greensand of British geologists, while its position directly below beds almost beyond doubt representing the Lower or Gray Chalk, precludes its reference to any higher stratigraphical position." Professor Meek consequently regards the Dakota group as the American equivalent in whole or in part of the European Upper Greensand.

Overlying the Fox Hills group, the highest of the undoubted cretaceous series, come what the author calls the "Fresh and Brackish-water Lignite Deposits," a series of sands and clays, with interspersed beds of impure lignite. These deposits are divided into two groups—the Judith River and Fort Union groups. The latter, which is regarded as the more recent of the two, is also much more widely spread than the other over the Missouri region. The chief interest attaching to these deposits, however, and especially to the older, or Judith River group, is to be found in the singular assemblage of fossil remains which they contain. This seems to mark them out as passage beds between the Cretaceous and Tertiary series. Thus the vertebrate remains found in them seem to point directly to Cretaceous affinities some of them being Dinosaurians related to *Iguanodon*, *Megalosaurus*, &c.; whilst associated with these are others, such as a tortoise belonging to an Eocene genus, and garfishes of the genus *Clastes*, which, with the remains of plants also found in the deposits, would seem to indicate an Eocene Tertiary date. Similar, if not identical, deposits are recorded as occurring in various parts of the country, and especially in Southern Wyoming, where a lignitiferous group, called by the author the Bitter Creek series, exhibits in a very striking manner the intermixture of Cretaceous and Eocene types above referred to, but with this remarkable addition, that some species of shells obtained from low down in the series exhibit striking Cretaceous affinities, whilst others from a higher horizon appear to belong to decidedly Eocene types. On the whole, it would appear that in the Judith River group and its equivalents in other localities, we have distinct traces of the transition from Cretaceous to Eocene conditions. The Fort-Union group appears to be of Eocene age.

The Wind River and White River groups, from which a few fossils are described in this volume, are of Miocene age. The former does not belong to the Upper Missouri region; the latter is a series of sands, clays and grits, forming what are known as the *Mauvaises Terres*, or "Bad Lands" of Nebraska, and it is from these deposits, which may have a total thickness of about 1,000 feet, that the extraordinary Mammalian remains lately described by Professor Marsh have been chiefly derived. The Mollusca obtained from these deposits, which are so rich in the remains of Vertebrata, are but few—only seven are here described by Professor Meek, and all are terrestrial or freshwater species.

Of the illustrations, which occupy 45 plates, we need only say that, as in all the publications of the American Surveys, they are abundant in quantity, and for the most part excellent in quality. In fact, in every respect Professor Meek's work on the Cretaceous and Tertiary Invertebrata of the Upper Missouri is one of the finest and most complete contributions to the

palæontology of any formation that we possess, and with the previous volumes of Professors Leidy, Cope, and Lesquereux it will materially assist in solving one of the most difficult problems in the Geology of Western North America, involving the relations of the lignitiferous deposits to the well-marked cretaceous rocks underlying them.

FERTILIZATION OF PLANTS.*

IT is probably well known to most of our readers that Mr. Darwin many years ago was led to the belief that cross-fertilization was a necessary process in many, perhaps in most plants, even though the organs of the two sexes might be present together in their flowers. The prime agents in effecting this he took to be insects, and his own researches on the Orchids, the Primulaceæ, and some other groups of plants, followed by the investigations of other naturalists, both in this country and abroad, have gone far towards establishing the truth of this generalization. The means by which the cross-fertilization of plants, by the contact of the pollen of one flower with the stigma of another flower, on the same or a different plant, is provided for, are indicated as follows by Mr. Darwin in his lately published book on "The Effects of Cross and Self-Fertilization." He says: "Cross-fertilization is sometimes ensured by the sexes being separated, and in a large number of cases by the pollen and stigma of the same flower being matured at different times. Such plants are called dichogamous, and have been divided into two sub-classes: proterandrous species, in which the pollen is mature before the stigma, and proterogynous species, in which the reverse occurs; this latter form of dichogamy not being nearly so common as the other. Cross-fertilization is also ensured, in many cases, by mechanical contrivances of wonderful beauty, preventing the impregnation of the flowers by their own pollen. There is a small class of plants, which I have called dimorphic or trimorphic, but to which Hildebrand has given the more appropriate name of heterostyled; this class consists of plants presenting two or three distinct forms, adapted for reciprocal fertilization, so that, like plants with separate sexes, they can hardly fail to be intercrossed in each generation. The male and female organs of some flowers are irritable, and the insects which touch them get dusted with pollen, which is thus transported to other flowers. Again, there is a class in which the ovules absolutely refuse to be fertilized by pollen from the same plant, but can be fertilized by pollen from any other individual of the same species. There are also very many species which are partially sterile with their own pollen. Lastly, there is a large class in which the flowers present no apparent obstacle of any kind to self-fertilization; nevertheless these plants are frequently intercrossed, owing to the prepotency of pollen from another individual or variety over the plant's own pollen."

The wonderful variety of arrangements all tending towards the same end, so admirably summed up in the preceding paragraph, is sufficient, as Mr.

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* "The Effects of Cross and Self-Fertilization in the Vegetable Kingdom." By Charles Darwin, M.A., F.R.S., &c. London: John Murray. 1876.

Darwin justly remarks, to warrant us in inferring that the plants referred to derive some great advantage from the process of cross-fertilization, and his present book is a record of the long series of experiments that he has undertaken with the purpose of ascertaining whether any such advantage does accrue to the plants by intercrossing, and if so, of what nature it may be. We may add that, from his observations, he is inclined to adopt for plants in general the aphoristic statement in which he summed up the results of his investigations of the Orchids: "Nature abhors perpetual self-fertilization;" but at the same time he by no means claims to be the absolute originator of this notion, which occurred to Andrew Knight as long ago as 1799, when he said: "Nature intended that a sexual intercourse should take place between neighbouring plants of the same species;" and subsequently both Kölreuter and Herbert entertained somewhat similar views. Still earlier, in 1793, C. K. Sprengel seems to have had an indistinct prevision of the prevalence of some such law as that enunciated by Darwin.

It would be impossible, without devoting to it more space than we have at command, to give anything in the shape of an analysis of the results published by Mr. Darwin in his present book, which is a wonderful record of patient investigation, directed by an intelligence of so high an order that one feels surprised, notwithstanding what we already know of Mr. Darwin's work, to see the two qualities involved in carrying on the researches and generalizing their results so strikingly combined in the same individual. Cross and self-fertilizations of innumerable flowers had to be effected, the seeds to be sown, the plants kept distinct, measured and weighed, and all these processes were continued in many cases through several generations, and the whole of the results obtained were then tabulated in such a manner as to show the evidence furnished by them for or against the opinion which the distinguished naturalist was desirous of testing. With but few exceptions the plants raised from cross-fertilized seeds had, as Mr. Darwin expected, an advantage, and often a considerable one, over those which sprung from seeds fertilized by the pollen of their own flower; but for the particulars of the experiments, many of which, having been made upon common garden plants, may easily be repeated by any one who feels an interest in such researches, we must refer our readers to the book itself. Many important observations are scattered through the volume, and the summary contained in the last four chapters is of great interest even to those who will not be at the trouble of studying the mass of facts given in the body of the book.

BRITISH FUNGI.*

THAT a third edition of Mr. Cooke's "British Fungi" has been called for is most certainly a matter for congratulation, as it is an indication that there must be an increasing number of people to whom the study of plants, as something more than pretty things, is of interest. This new edition has undergone but little alteration, but the text furnishes a good popular account

* "A Plain and Easy Account of British Fungi, with especial Reference to the Esculent and Economic Species." By M. C. Cooke, M.A., LL D. Third Edition, Revised. London: Hardwicke & Bogue. 1876.

of the more prominent British forms; and appended to it is a tabular arrangement of genera, which, if carefully used, will enable the student to discriminate at least the genus of any ordinary Fungus that he may meet with. The illustrations are particularly good; they consist of a considerable number of woodcuts and of twenty coloured plates, the figures in which are exceedingly pretty and very characteristic. The esculent species receive particular attention.

GEOLOGY OF ENGLAND AND WALES.*

THAT Britain may fairly claim to be the birthplace and nursery of the modern science of geology, is no doubt due to some extent to the presence amongst us, during the last century, of men with special talents for geological research, but it is quite certain that the geological structure of the country has had much to do with it. It is true that Hutton and his commentator Playfair laid down the principles which are now recognized almost everywhere as the true foundations of geology; that William Smith, by his stratigraphical researches, and especially by his recognition of the value of fossil evidence in the discrimination of deposits, laid the first stone of an edifice which all subsequent workers in the same department have merely contributed to finish; but it may be questioned whether British geologists would have done so much, and held so prominent a position among the students of their science, had it not been for the peculiar advantages presented by their native island, and especially by its southern division, for the study of geological facts. Nowhere else in the world do we find so complete a series of stratified deposits brought together within so small a space. From the highest glacial and post-glacial beds down to the oldest fossiliferous deposits the British geologist may work his way practically without leaving his own country, and although his acquaintance with geology thus acquired may perhaps be a little one-sided, he will be quite prepared to appreciate and work into the framework of his personal knowledge those facts which are only revealed in other countries.

Under these circumstances it is perhaps singular that we have so few books professing to be guides to the study of the geology of a country so interesting and important. It is true that most of our manuals of geology take the structure of this country as their foundation, and treat the geology of other parts of the world as more or less subsidiary to it, so that they may, to a greater or less extent, serve as such guides; but they are generally deficient in that local definiteness, if we may use the expression, which would render them most useful to the student. The well-known "Outlines of the Geology of England and Wales," by Conybeare and Phillips, published in 1822, and to a certain extent and over a limited area the "Geology of the Thames Valley," by Professor John Phillips, which appeared in 1871, are the only

* "The Geology of England and Wales: a Concise Account of the Lithological Characters, leading Fossils, and Economic Products of the Rocks; with Notes on the Physical Features of the Country." By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales. With Map and Woodcuts. London: Longmans, Green & Co. 1876.

general handbooks we possess in which the local element is sufficiently prominent, and the former of these has been so left behind in many points by the progress of geology during upwards of 50 years, that although still of great value as a book of reference, its statements require to be greatly modified to suit them to modern ideas.

It is therefore with great pleasure that we call the attention of our readers to the admirable little handbook of the Geology of England and Wales lately published by Mr. Horace B. Woodward, of the Geological Survey, the son of the late Dr. S. P. Woodward, whose "Manual of the Mollusca" must be well known to most of them. In this book, Mr. Woodward has brought together in systematic form the results of the best investigations that have been made in English geology, and we find that even the most recent publications have been laid under contribution. He commences with a short introduction on the principles of geology, and then proceeds at once to the description of the stratified rocks, from the Laurentian or Pre-Cambrian formations up through the long series of fossiliferous rocks, to the most recent alluvial deposits. In his classification of the older Palæozoic strata he adopts the views of Sedgwick, as lately revived by Mr. Hicks and other geologists, placing the boundary between Cambrian and Silurian at the base of the Lower Llandovery rocks. As an innovation upon generally received opinions, we may note that Mr. Woodward cuts the knot of the difficulty as to the line of separation between the Palæozoic and Mesozoic rocks, by shifting the Permians bodily into the latter series, where he makes them form, with the Trias and Rhætic beds, a primary division for which he adopts Conybeare's term "Poikilitic." In this, at all events as regards the position assigned to the Permians, we cannot help thinking that the author has made a step in the wrong direction—the fossils of the Permian series are so decidedly Palæozoic in their character, that if a line is to be drawn anywhere it ought at least to be above them.

In all other particulars we can only repeat that Mr. Woodward's book is an admirable one. That it is of necessity to a great extent a compilation will be evident to all; but there are compilations and compilations, and in the present case the author has selected the best authorities and used his own judgment in the employment of the materials they afford him, guided no doubt in many cases by his own experience gained by several years hard work in the field. Moreover, he is not content with calling on his readers to accept what he tells them, simply because he says it, leaving them to suppose that no other view is by any means admissible; but in all disputed or doubtful cases, he briefly indicates the evidence on both sides, and places the matter in such a form, that those who choose the path that he has rejected, may still make use of his lamp as a guide for their feet.

Besides describing the characters of the different formations and their divisions, including those minor subdivisions which have received local names, and indicating the localities in which exposures of the various rocks may be studied, Mr. Woodward notices the economic products of the rocks as he passes them in review, and in most cases their influence on the overlying soil. He has also a special chapter on the effect of geological structure and denudation on the scenery of the country. The fossils indicated under the different formations are not numerous, as the author says that he does

not consider long lists without figures of much use to the student, but in all cases some of the most characteristic forms are noticed.

Among the concluding chapters we have one on "Sub-aërial phenomena;" such as the production of springs, caverns, peat, soils, &c.; and another on igneous and metamorphic rocks and on mineral veins. An appendix contains a glossary of geological terms, which is generally, though not quite always, correct in its definitions, and a table of the classification of the animal kingdom with special reference to palæontological purposes. The illustrations consist of diagrammatic sections and a good many very nice views; the former might perhaps be increased in number with advantage. There is also at the beginning of the volume a small coloured geological map showing very clearly the distribution of the various formations.

In conclusion we may say that Mr. Woodward's treatise will be found an excellent guide for all who wish to study the geology of this country, and at the same time it will be of considerable value to more advanced geologists who may often find it exceedingly convenient to refer to for particulars of the relations of those minor divisions in the series of deposits, the details of which are so apt to slip out of even the most tenacious memory.

AQUARIA.*

SINCE Mr. Warrington invented the aquarium, some five-and-twenty years ago, the appreciation of such means of studying aquatic animals has spread very widely, both in this country and abroad. Naturally there have been an abundance of books, good, bad, and indifferent, written as guides to the management of the aquarium and its inmates, but few of them can claim to tell their story in a more practical and at the same time pleasant fashion than Mr. J. E. Taylor in his little volume now before us. In it he gives a brief account of the history of the aquarium, followed by a chapter on the principles on which the formation of an aquarium is founded, and then proceeds to explain the management of fresh water and marine aquaria of various kinds, and the mode of stocking them with tenants, and to sketch the natural history of some of the more interesting objects, both animals and plants, which may with advantage be kept in these indoor pools. In these brief biographical sketches Mr. Taylor, after his wont, puts all that he has to say in a most readable form, but at the same time we are glad to see that he does not lose sight of the fact that the aquarium is to be regarded as a means not only of amusement but of instruction; and he loses no opportunity of indicating in what manner the supposed toy may be made subservient to the latter purpose. The little book is copiously and very nicely illustrated, and may be recommended as an admirable gift-book for any young people whose parents and guardians are not deterred by the fear of possible "messes" from encouraging in their charges a taste for the practical study of the natural history of our seas and fresh waters.

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* "The Aquarium; its Inhabitants, Structure, and Management." By J. E. Taylor, Ph.D., F.L.S., F.G.S., &c. London: Hardwicke & Bogue. 1876.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

Menhirs.—Dr. Thomas Inman has communicated to the Literary and Philosophical Society of Liverpool some notes on the mode in which gigantic stones, such as those of Stonehenge, and the menhirs of Brittany, may have been erected in the positions they now occupy. His observations are founded on the statements of the late Mr. Greey, a civil engineer, who saw a block of stone, weighing from 20 to 30 tons, carried up a hill to a height of 4,000 feet, in the course of three or four hours. This was apparently among the Khasia hills, where, according to Major Godwin-Austen, upright stones of large size are very common. The stone was fixed upon two long trees, placed parallel to each other at its two ends, and projecting for a considerable distance on each side of the megalith. Between these trees, and parallel to the stone, several cross-ties were lashed, dividing the cradle on each side into parallelograms, in each of which a considerable number of men could stand, each having a firm hand-hold upon one of the cross-ties. By taking five of the cross-ties on each side of the stone Dr. Inman reckons that there would be room for 600 bearers, which, taking the block at 26 tons, or 520 cwt., would give less than 1 cwt. for each man to carry. His informant did not count the men, but he saw them lift the frame with the block of stone and walk off with it easily to the top of a hill 4,000 feet high. Its erection when there was effected in an equally simple manner. A hole was dug where it was to stand, the lashings securing one end of the stone were cut, and the ties removed, so as to allow the end of the stone to fall into the hole; ropes were attached to the other tree and hauled upon until the stone was brought into an erect position, when the hole was filled in and the work completed. The whole process does not occupy more than three or four hours, and the work is done gratuitously, all members of the community, according to Major Godwin-Austen, being under an obligation to assist in so meritorious a work, the menhirs being generally, if not always, erected in honour of some deceased member of a tribe or family through whose influence in the other world prosperity is supposed to have accrued to the family or clan.

ASTRONOMY.

The Sun's Rotation Measured with the Spectroscope.—We have to record the most remarkable achievement yet effected with the spectroscope, though involving no discovery, at least no new result which can as yet be regarded as demonstrated. It will be within the knowledge of our readers that Secchi, having failed to recognize the effect of the sun's rotation by the spectroscopic method of measuring motions of recession and approach, expressed doubts as to the validity of the method itself. These were partly based on an erroneous estimate which in some inexplicable way Secchi had formed respecting the actual rate of the sun's rotational movement at the equator, this rate in reality amounting to only a small fraction of Secchi's estimate. Huggins also failed in obtaining spectroscopic evidence of the solar rotation, though he used a spectroscope made by Browning for Spottiswoode, (the only one of the kind ever made), on a plan devised by Proctor (the automatic battery S-shaped and twice-acting), giving a dispersive power equal to that of nineteen equilateral prisms of flint glass. The observers at Greenwich have not as yet announced the final results of their attempt to measure the sun's rotation spectroscopically, though from the general statement made by Sir G. Airy it would seem they have successfully dealt with the problem. In the meantime it has been mastered by Professor Young, of Dartmouth College, Hanover, N.H. Employing one of the marvellously effective ruled plates, made by Dr. Rutherfurd, which give diffractive spectra of singular purity, he has succeeded in unmistakably recognizing the spectroscopic effects of the sun's rotation. He regards his instrumental means with so much confidence that he relies even upon the difference between his results and those due to the direct measurement of the solar rotation. He finds the sun's atmosphere to be travelling somewhat faster than the visible solar surface. We are not sure that his confidence in this particular detail of his results is justified by the performance of his spectroscopic combination in other cases. The difference of rate, about ten miles per minute, seems too small to be measured in this way. But, in any case, it is satisfactory to find that a motion so small as that due to the sun's rotation, about one mile per second (or a difference, for opposite points of his equator, equal to about two miles per second), can be recognized by the spectroscopic method, as this enables us to regard with considerable confidence the measurements of stellar motions of recession and approach, amounting, as these often do, to twenty, thirty, or even so many as fifty miles per second.

Spectroscopic Measures of Motion at Greenwich.—The Astronomer Royal, in communicating the results of measurements of star motions, comments on objections raised by Professor Secchi. These are on the whole satisfactorily disposed of. Indeed some of Secchi's objections indicate a very imperfect acquaintance with the rules for determining the value of results obtained from a series of measurements. The measures of star motions agree on the whole fairly with those obtained by Huggins. Measures of the displacement of lines in the spectrum of the moon and Venus have been

made, to test the accuracy of the method. In the case of the moon the motion in the line of sight is insensible, and the result of the observations is in very satisfactory agreement with this. The motion of Venus has been observed at both elongations, the comparison being made in some cases with the bright lines of hydrogen or magnesium, in others with the sky spectrum. The observations of the western elongation were made in the forenoon. The calculated motions have been deduced from the daily change of distance from the earth, as given in the "Nautical Almanac." The observed motion is rather larger than the calculated, both for the approach and recession. Sir G. Airy remarks that this may be due in part to the disturbing effect of the juxtaposition of two nearly coincident lines; but it seems not impossible that we have here an indication of the fact, already shown to be deducible from the observations of the recent transit, that the sun's distance has been recently under-estimated. In Sir G. Airy's paper the sun's distance is taken as 91,260,000 miles, whereas the true distance appears to be about 92,000,000 miles. And of course our estimates of all the motions taking place within the solar system are affected in proportion to any error in the assumed distance of the sun. It is interesting to notice that we have in this spectroscopic method of measuring motions of recession and approach a means (which one day may prove exceedingly effective) of determining the dimensions of the solar system.

Many attempts were made to measure the displacement of the F. line due to the rotation of Jupiter, but for a long time these were frustrated by atmospheric obstructions. On one occasion, however, the spectrum was seen fairly well, and measures obtained which give a result in remarkable accordance with the calculated value. "It is to be remarked," says Sir G. Airy, "that the method can be applied to Jupiter with peculiar advantage, as the equatorial velocity is very large, and its effect doubled by reflexion. Thus the observed displacement corresponds nearly to four times the equatorial velocity."

In measuring the rotation of the sun the great point aimed at was to prevent the sun's heat from in any way affecting the position of the line observed, by expanding the slit unsymmetrically. The precautions adopted appear to have been sufficient, having, says Sir G. Airy, "removed the sources of error to which results by former observers appear to have been exposed." Particular care was also taken to avoid any bias from previous knowledge of the direction in which a displacement was to be looked for, the limb under observation not being determined till after the bisection had been made. "In the calculated motion," says Sir G. Airy, "there is some uncertainty, as it is doubtful how far the period of rotation deduced from sunspots will apply to the chromatosphere, to the rotation of which the observed displacement is due. There would appear to be no reason to suppose that it takes part in the general drift depending on the latitude, which has been remarked in sunspots." These spectroscopic observations at Greenwich are on the whole very satisfactory.

Spectra of the Planets.—M. Vogel has made researches upon the spectra of the planets, for which a prize has been awarded to him by the Copenhagen Academy. He finds the light of the planets in general to show the principal Fraunhofer lines. He considers the idea of a light proper to Jupiter and Saturn, as explaining their brightness, to be unfounded; for "the

"presence in the spectra of these planets of lines and bands of absorption, identical with those produced in our atmosphere, seems," he says, "to prove the existence of aqueous vapours in the gaseous envelopes of these planets, so that it seems difficult to suppose the temperature of their surface high enough to cause an emission of light." The argument is weak, however. We know that in the higher regions of our air there are often, if not generally, minute crystals of ice, forming light cirrus clouds. If an inhabitant of Venus or Mercury could become cognizant of the existence of these ice-crystals, he might infer, from M. Vogel's method of reasoning, that the temperature of the earth's surface could not be higher than the freezing point of water. He would be mistaken; and quite probably M. Vogel is mistaken, on this particular point. "The solar and the planetary spectra differ," he says, "in that the latter have absorption bands, more or less intense, in the less refrangible parts; and these may be attributed to the atmospheres of the planets. The further a planet is from the sun, the more preponderating is the influence of its atmosphere. The interior planets, Mercury and Venus, have only very weak absorption bands in the red and yellow, which are coincident with lines produced by the passage of light through our atmosphere. Mars presents the same bands, but more marked. In the spectra of Jupiter and Saturn, there is, besides these bands, a very intense band in the red; and all the more refrangible part (violet and blue) is greatly weakened, without bands being distinguishable. Lastly, the spectra of Uranus and Neptune are crossed everywhere with broad and intense absorption bands." These results agree in the main with those already obtained by Mr. Huggins. (See also an article by Mr. R. A. Proctor, "On the Condition of the Larger Planets," at p. 38 of the present number.)

Effect of Sunspots on Terrestrial Climates.—Professor S. P. Langley has endeavoured to ascertain by how many points of a degree Centigrade the earth's mean annual temperature necessarily varies between a year of maximum and a year of minimum spot areas, so far as the immediate effect of these on the solar thermal radiations is concerned. To do this, it is necessary, he says, "First to procure from experiment, trustworthy measurements of the relative amounts of photospheric, penumbral, and umbral radiation; secondly, to determine the relative photospheric, penumbral, and umbral surfaces, in a maximum and minimum year, and (having suitably combined these data) to show, thirdly, within what specific limits we can assert that the terrestrial temperature will necessarily be changed." One rather important point may be added as absolutely essential to the formation of an opinion from direct observation, viz., we must determine whether the radiation from the photosphere remains unchanged, or if not, how it varies, with the changing condition of the sun as regards the spots. It may be that the increased activity certainly prevailing when spots are numerous increases the general radiation from the photosphere, and that, too, in a much greater degree than the sunspot area reduces the extent of photospheric surface. Having unfortunately omitted to make any observations bearing on this point, probably the most important in the whole inquiry, Professor Langley's results are *pro tanto* reduced in value. They are these,—that (neglecting the point just mentioned) the least change in

solar heat due to sunspots, amounts to one-tenth per cent. of the whole radiation (whose thermometric effect registered here is a change of at least 70° C.): whence we find 0°·063 C., as the *least* change in terrestrial temperature which we can attribute to the direct action of the spots; and the *greatest* change in terrestrial temperature which can be due to this cause amounts to 0°·29 C. Thus "sunspots" do exercise a direct and real influence on terrestrial climates by decreasing the mean temperature of this planet at their maximum, but the decrease is so minute that it is doubtful whether it has been directly observed or discriminated from other changes."

Equatorial Motion with an Altazimuth Stand.—Lord Lindsay describes a method of making an ordinary altazimuth telescope follow a celestial body along a parallel of declination, which many who have used an altazimuth in astronomical observation must have thought of. It is manifest that when a telescope is sweeping a declination parallel, a point of the tube lying on a line drawn parallel to the collimating axis through the intersection of the horizontal and vertical axes, must travel in a circle having its plane parallel to the equator and its centre on the polar axis through the last named point of intersection. Its distance, therefore, from any point on this polar axis must remain unchanged. If then such a point of the tube be connected with a fixed point lying on this polar axis, the telescope will sweep a declination-parallel, if turned around the vertical axis in such sort that the connecting string remains stretched. As the length of the connecting string can be readily altered, the telescope can be made by this arrangement to sweep out any declination-circle. The idea is not a new one. It was long ago suggested by Sir G. Airy, with, however, a somewhat inconvenient arrangement, the fastening string being attached above and behind (or north of) the pivot. Lord Lindsay suggests a string attached in front (or south) of the pivot; in fact, from a point on the tube near the object-glass to a fixed point suitably placed due south of the vertical axis. In the illustration accompanying Lord Lindsay's paper the point near the object-glass is not correctly placed; it is on the tube itself, whereas the pivot (or intersection of the axes of motion) is about 1½ inch from the tube.

The Planet Vulcan.—Some excitement was occasioned among the believers in Vulcan by the announcement that in April last M. Weber, at Petcheli had seen a round spot on the sun, which a few hours later had vanished. After Wolfe, Leverrier, Moigno, and others, had expressed their conviction that this was a real transit of Vulcan, and had urged astronomers to look out for another transit in October, it was discovered that Weber's spot had been seen at the Madrid Observatory, and had been photographed at Greenwich. It was seen, however, and photographed as an unmistakable sunspot, and Weber's view of it as a round black disc which might have been a planet in transit, was due simply to the small power of his telescope. We wonder how many reported "transits of Vulcan" would thus have been explained away if a systematic observation of sunspots had been made in former years as at present?

Total Eclipse of the Moon, partly visible at Greenwich.—On the evening of Feb. 27, the moon will rise at Greenwich already partly obscured by the earth's penumbra, but the true shadow will not encroach upon the moon's disc until 1½ min. later, or at 29½ min. past 5, P.M. Total phase will begin

at 6h. 27·3m.; middle of the eclipse will occur at 7h. 15·3m.; and of total phase at 8h. 3·3m.; and last contact with the shadow at 9h. 1m., the penumbra not quite passing off until 9h. 56.7m.

Partial Eclipse of the Sun.—The partial eclipse of the sun on March 15 will not be visible at Greenwich. It will not be of any importance.

Planetary Opposition.—The only planet which comes to opposition during the quarter ending March 31 is Uranus, which will be in opposition at about 6 o'clock on the morning of Feb. 11.

New Star in Cygnus.—Early in the evening of November 24, Professor Schmidt, the director of the observatory at Athens, observed a star of the third magnitude in the constellation Cygnus in R A. 21 h. 36 m. 50·41 s., N.P.D. 47° 43′ 21·5″. At midnight its light (very yellow) surpassed that of η Pegasi, rated by Sir J. Herschel as of magnitude 3·72 (α Centauri being 1). On December 5, M. Paul Henry, of the Paris Observatory, estimated the star as of the fifth magnitude, and its colour greenish, almost blue. M. Cornu examined it unsuccessfully on Dec. 2, but on Dec. 5 he succeeded in making several measures, though much interrupted by clouds. His results are thus presented—"The spectrum of the star is composed of a certain number of bright lines standing detached on a sort of luminous background, almost completely interrupted between the green and blue, so that at first sight the spectrum appears to consist of two separate parts. In order to study it qualitatively I made use of a spectroscopic eye-piece, specially constructed, which utilizes the greatest portion of the light, and allows us to vary its concentration." Three of the bright lines observed appear to be lines of hydrogen, another line seems to be identified with the double line D of sodium, though there is nothing to prevent us from regarding it as agreeing rather with D_3, the well-known yellow prominence line. A fifth line agrees with the triple line *b* of magnesium. Of two remaining lines, one seems to be coincident with the line (1474 Kirchhoff) observed in the spectrum of the solar Corona and the Sierra. M. Cornu closes an interesting summary of his observations with some "mighty foolish" remarks. "Notwithstanding the great temptation there exists," he says, "to draw from facts inductions relative to the physical condition of this new star, its temperature, and the chemical reactions of which it may be the seat, I shall abstain from all comment and all hypothesis on this subject; I believe the facts necessary to arrive at a useful conclusion are wanting, or at least at a conclusion capable of verification. Whatever attractions these hypotheses may have, it is necessary not to forget that they are unscientific, and that far from serving science they tend greatly to trammel her," which proposition "we for the present content ourselves with modestly but peremptorily and irrevocably denying." M. Cornu's remarks seem intended as a reflection upon Mr. Huggins's method of treating the questions raised by the outbreak in Corona in May 1866. The hypotheses then suggested by Mr. Huggins led almost directly to the successful investigation of the solar prominences; and neither the method so successfully used by M. Cornu, nor the facts on which he bases his interpretation would have been known to men if all students of science had been content to render their direct observations as barren and unproductive as M. Cornu does his.

BOTANY.

New Colouring Matter from the Tomato.—According to M. Millardet the cells of ripe tomatoes contain a great quantity of acicular crystals of a colouring matter, for which he proposes the name of *solanorubine.* It is insoluble in water, soluble in alcohol at a high temperature, but readily soluble in bisulphide of carbon, chloroform, and benzole. It is bleached by exposure to light, possesses no fluorescence, but exhibits very characteristic absorptions in the spectrum, namely:—Two bands in the green, coinciding with *b* and F, a band between F and G, and an obscurity near G. In M. Millardet's opinion solanorubine is formed directly from the colouring matter of chlorophyll.

The Vitality of Seeds.—Professor Ernst, of Caracas, writing in a late number of the "American Naturalist," states that a curious case of vitality is afforded by a very common weed, shepherd's-purse, which, strange to say, is so rare at Caracas that it had not been met with in botanical excursions covering a period of twelve years. Two years ago, in the southern part of the garden of the monastery, a place was graded for the erection of a building. A great deal of soil was removed, and a wholly fresh surface was thus uncovered. Upon this spot many weeds sprang up, and among them thousands of specimens of *Capsella bursa-pastoris*, or shepherd's-purse. Professor Ernst concludes that in this case, the seeds had remained dormant in the soil for an unknown period. These cases belong to the same class as those mentioned by Hoffmann, and given in the January number of the "American Naturalist."

Flora of the Guadeloupe Islands.—Mr. S. Watson publishes in the "Proceedings of the American Academy of Sciences" (vol. xi.) a paper on this subject, in which he concludes that this little flora as a whole is to be considered a part of that of California, as distinct from the flora of Mexico. It may be inferred also that it has not been to any great extent derived from California by any existing process of conveyance and selection, but that it is rather indigenous to its present locality. Moreover, while it would indicate a connection at some period between the island and the main-land to the north, yet the number and character of the peculiar species favour the opinion that they are rather a remnant of a flora similar to that of California, which once extended in this direction considerably to the southward of what is now the limit of that flora upon the main-land. And, finally, the presence of so many South American types suggests the conjecture that this, and the similar element which characterizes the flora of California, may be due to some other connection between these distant regions than any which now exists, and even that all the peculiarities of the western floras of both continents had a common origin in an ancient flora which prevailed over a wide, now submerged area, and of whose character they are the partial exponents.

Sowerby's Drawings of English Fungi.—We learn from the "Journal of Botany" that the Rev. M. J. Berkeley has presented to the Department of Botany, in the British Museum, James Sowerby's original drawings for the "English Fungi," published in 1797-1809, consisting in all of 530. The

Museum already possessed the clay models made by Sowerby during the progress of the work, as well as the original drawings for the plates of "English Botany," in which it will be remembered the Fungi were not included. Mr. Berkeley's gift, therefore, very usefully completes the series of original illustrations of British plants in the Museum.

Age and Leafing of Trees.—M. A. de Candolle has an article in the "Archives des Sciences," which is thus abstracted in the "Academy." He first quotes the replies to queries on the subject from Prof. Decaisne, of Paris, and Prof. Caruel, of Pisa, who had both made observations at his request. From their observations it would seem that age had nothing to do with the date of the leafing of trees, or that the differences observable were simply individual peculiarities. In some cases the old and young trees of the same species burst their buds at the same time, while in others the older, in others the younger, developed their leaves first. But the most valuable and original material for affording some light on this subject was "a series of observations made upon two trees of the same height above the ground during fifty-seven and sixty-eight years respectively." These observations were made upon two horse-chestnut trees at Geneva, and are regarded by the learned author as perfectly trustworthy. The average date of the leafing of the one longest under observation is 94·9 days after January 1, and of the other 93·61 days. Dividing the whole term into six, four, or two periods of equal duration, the average dates exhibit no essential progression or retrogression. But it is worthy of remark that during the third period of seventeen years, 1842-58, the average is 2·5 days later than during the fourth period, 1859-75. Observations on a grape-vine, by Messrs. Macleod and Lanezweert at Ostend, from 1843 to 1875, indicate a gradual forwarding of the date of leafing. Thus, during the first period of sixteen years the average date was 16·6 days later than the average of the succeeding seventeen years. But De Candolle thinks this may be due to diminished vigour or pruning and other artificial conditions. In a word, the age of a healthy tree exercises no appreciable influence.

CHEMISTRY.

Artificial Colouring of Wine.—The adulteration of wine seems to be a growing evil in France, and, of course, after the addition of water, something is required to restore the rich colour of the clarets and burgundies. Fuchsine appears to be the favourite substance for this purpose, and French chemists are constantly bringing forward processes for its detection in wines. It is just possible that a knowledge of how to proceed in such cases may not be altogether useless even in England. The following are two of the simplest processes. M. Lamattina recommends that 100 grammes of the suspected wine should be mixed with 15 grammes of coarsely powdered peroxide of manganese, shaken for about a quarter of an hour, and filtered, when, if both the wine and the peroxide of manganese are pure, the filtrate will be colourless. But should the peroxide of manganese contain iron, which is indicated by the yellowish colour of the filtrate, any fuchsine that may be present will combine with the iron, and remain, as an insoluble compound,

on the filter. The mass on the filter must in this case be treated with alcohol, which will dissolve the fuchsine, whilst the natural colouring matter of the wine remains insoluble. M. Didelot's method is still more simple. He places a little ball of gun-cotton in a test-tube with some of the wine to be examined, shakes the whole strongly for a short time, and carefully washes the cotton in several waters; if the wine be pure, the cotton becomes white again, but the tint given to it by artificial colorants persists. The actual substance employed may generally be recognized by the addition to the coloured cotton of a few drops of ammonia. The colour is discharged when fuchsine has been used, rendered violet when the colouring matter is orchil, and greenish when it is elder juice.

Atomic Weight of Selenium.—By an investigation of numerous selenium compounds, MM. Pettersson & Ekman have endeavoured to ascertain the precise atomic weight. As a mean of seven direct analyses, they obtained the number 79·01. By reducing selenous acid by sulphurous acid, and collecting and drying the precipitate, the number 79·08 was obtained as the mean of five determinations, and this they believe to be very nearly correct. (Berlin Chemical Society, Sept. 1876.)

Physical Properties of Gallium.—M. Boisbaudran has prepared a small quantity of nearly pure gallium, and finds that its melting point is about 29·5° C. (= 85·1° F.), so that it is fused by the heat of the hand. When once liquefied, it exhibits the phenomenon of surfusion in a very remarkable manner, remaining liquid for more than a month as a globule capable of being divided and reunited by the blade of a knife, in a room of which the temperature often fell below the freezing-point. By contact with a piece of solid gallium, it was immediately solidified. It crystallizes readily, only oxidizes at the surface when heated to redness, and does not volatilize. It density is about 4·7, so that in this, as in some other respects, it stands between aluminium and indium. ("Journ. de Phys.," Sept. 1876.)

Liquid Carbon Dioxide in Mineral Cavities.—On heating a microscopic slide of quartz containing fluid cavities only to a moderate temperature, Mr. Hartley was surprised to find that the liquid, previously perfectly visible under the microscope, had disappeared. On cooling, the liquid re-appeared, accompanied by a sort of flickering movement within the cavity. Experiments on fluid cavities in various minerals made by Brewster in 1823, showed that the liquids all disappeared below 88° F., that their expansion between 50° and 80° F. was 32 times that of water, and their index of refraction 1·2946 in topaz and 1·2106 in amethyst. From these results Simmler, and later, Sorby and Butler, concluded that the liquid must be carbon dioxide. The author sought carefully to determine the critical point of the liquid, which he did by immersing the slide in water of known temperature, removing, wiping hastily, and examining. As a result, it appeared that the critical point lay between 30·75° and 31° C., that point for pure carbon dioxide having been fixed by Andrews at 30·92° C. In further corroboration of this view is the fact that when water was also present in the same cavity, the other liquid floated on it; the density of carbon dioxide being 0·83 at 0° C. and 0·6 at 30° C. Moreover, Geissler has shown the presence of this gas in quartz by its spectrum in a vacuum tube in which the quartz was broken. In explanation of the formation of these fluid cavities,

the author supposes the silica in hot solution to have come in contact with a limestone under pressure, setting free carbon dioxide, which being enclosed in the crystal cavities along with water would on cooling condense to a liquid.—("J. Chem. Soc.," xxix, 137.)

Volatility of the Alkaline Earths.—A paper was recently read before the Chemical Society by Professor J. W. Mallet on the above subject. The author has ascertained by a series of carefully made experiments that lime, baryta, or strontia heated in contact with metallic aluminium to a very high temperature in a carbon crucible, suffers an appreciable loss of weight, in some instances to the extent of more than 3 per cent., indicating that the alkaline earth must have been partly reduced and the metal volatilized. This supposition is confirmed by the observation of the flame of the carbon monoxide which is given off, the characteristic lines of the metals being distinctly visible when it is examined with the spectroscope.

GEOLOGY AND PALÆONTOLOGY.

Submarine Upheaval in Greece.—M. J. de Cigalla writes from Corfu, to the French Academy of Sciences, describing a curious upheaval of the sea bottom which has occurred in the little bay or port of Karavossera, in the Gulf of Arta. In November 1847 and February 1865, after some shocks of earthquake, a very dense sulphurous vapour issued from the bottom of the sea; this killed great numbers of fishes and other marine animals, and rendered the sea milky as far as Previsa. These sulphurous emanations still continue, especially when the wind is in the south, but they are not sufficient to cause any destruction of animals. Previous to 1847 the spot from which the emanations proceeded had a depth of 8 fathoms according to the charts, but in the spring of the present year Lieut. Miaulis, of the Greek Navy, found that the bottom had risen in the form of a cone, having a circumference of about 300 fathoms, and with its apex only 2 fathoms 4 feet below the surface of the sea. No increase of temperature was perceptible in the sea, but objects sunk at this part, and left for a time, are said to become encrusted with sulphur.

Two New British Formations.—There are certain things that demand courage, and one of them is the establishment of a new British geological formation. Nevertheless, Mr. Hicks has ventured to introduce two new divisions among those ancient rocks of the St. David's promontory, of which he has successfully constituted himself the historian. The rocks thus honoured form the central ridge of the promontory, and were formerly regarded as consisting of intrusive syenites and felstones; but, according to Mr. Hicks, this ridge is entirely composed of altered sedimentary rocks of earlier date than any Cambrian deposits, the conglomerates at the base of the latter being chiefly made up of pebbles of these rocks. In the ridge Mr. Hicks has recognized two distinct and perfectly unconformable series. The older of these, occupying the centre of the ridge, consists of quartzites and altered shales and limestones, has a N.W. and S.E. strike, and dips at a very high angle; the newer series, composed of altered shales, and having

at its base a conglomerate of pebbles from the older rock, has a strike nearly at right angles to that of the latter, upon both flanks of which it rests. Mr. Hicks has indicated certain points of resemblance between these pre-Cambrian rocks and the Laurentian of Canada, the Malvern Rocks, and others also of pre-Cambrian age in Scotland and elsewhere; but he thinks it the safest course to abstain for the present from attempting any definite correlation of them, and therefore proposes to distinguish the two series by names referring to the localities in which they occur, calling the older rocks Dimetian, from the Latin name of the district of St. David's, and the newer ones Pebidian, after the district of Pebidiog, in which they are very characteristically shown. The exposure of the Dimetian series leads him to ascribe to those rocks a thickness of at least 15,000 feet; the Pebidians are apparently of considerably less thickness, but they are in most parts more or less concealed by the Cambrian deposits which overlie them unconformably. A great mass of the Pebidian ocks is exposed to the north-west of St. David's, forming a band running nearly parallel to Ramsey Sound; and at the south-western extremity of Ramsey Island they form a bold hill about 400 feet high, on the east side of which a fault, with a downthrow of at least 14,000 feet, has brought the Arenig beds into immediate contact with the pre-Cambrian rocks. ("Proc. Geol. Soc.," Nov. 22, 1876.)

American Pterodactyles.—Professor Marsh has recognised the fact that all the known *Pterosauria*, or flying lizards of North America, which have hitherto occurred only in the Upper Cretaceous deposits of Kansas, and are remarkable for their large size, some of them having an expanse of wing of not less than 25 feet, are distinguished from their Old World relatives by an entire absence of teeth in both jaws. This is the more interesting, as it is in these very deposits that Professor Marsh has discovered the remains of birds which violate all the zoological proprieties by possessing true teeth imbedded in the jaws. Of these Pterodactyles, for which Professor Marsh has established the new order Pteranodontia, at least six distinct species, have been recognized, five belonging to the genus *Pteranodon*, which amongst other characters, presents the peculiarity of having the scapula firmly co-ossified with the coracoid, and having an oblique articular face at its distal end; and one to his new genus *Nyctosaurus*, in which the above characters are wanting. The type of the new genus was previously described by Professor Marsh under the name of *Pteranodon gracilis*. It seems to have been a middle-sized animal, measuring from eight to ten feet across the expanded wings. (Silliman's "American Journal," Dec. 1876.)

American Tertiary Mammals.—The continuation of Professor Marsh's researches upon the remains of Mammalia from the Eocene deposits of the Rocky-Mountain region has revealed a new genus of equine mammals, allied to *Orohippus*, but of an earlier and less specialized type, apparently in the direct ancestral line, for which he proposes the name of *Eohippus*. It is distinguished by having the last premolar above and below similar to the next premolar in front of it, and not like the first true molar as in *Orohippus*. The dental formula is the same in both. As in *Orohippus* the fore-foot has four, and the hind-foot three digits; but there is in addition a rudiment of the outer, or fifth metatarsal. Two species are noticed, namely *Eohippus validus* from New Mexico, and *E. pernix* from Wyoming.

Also a new genus of Porcine animals allied to *Elotherium* (Pomel), and *Helohyus* (Marsh), but differing from them in having a premolar less; the last lower molar has a distinct posterior lobe. This genus, according to the author, affords an interesting example of an extinct form outside of the ancestral line which terminated in existing pigs. The species, *Parahyus vagus*, which was about the size of the existing Wild Boar, is from Wyoming.

These pigs were probably persecuted by a carnivore about the size of a large wolf, whose remains are found in the same deposits. In its general characters this animal, which Professor Marsh calls *Dromocyon vorax*, closely resembled *Hyænodon*. It had apparently only four lower incisors, and seven lower molars, on each side, the last very small. The top of the skull had an enormous sagittal crest. Another form, belonging to the peculiarly American order Tillodontia, is described as *Dryptodon crassus*, and appears to have been about the size of a tapir. This is from New Mexico. ("Silliman's Journal," Nov. 1876.)

A new American Crinoid.—"Silliman's Journal" for July states that among the many interesting fossils recently received from the West by the Yale College Museum, is a new Crinoid from the cretaceous of the Uinta Mountains and of Kansas. No Crinoids from the American cretaceous have hitherto been described, and for the discovery of this species we are indebted to Professor O. C. Marsh, who has done so much to bring to light the geological treasures of the West. The Crinoid in question belongs to the group Astylidæ, or free Crinoids, and, as suggested by Professor Marsh in his earliest paper on the Geology of the Uinta Mountains, is allied to the genus *Marsupites* of Miller. From that genus, however, it differs widely in the number and arrangement of its plates, in having apparently ten arms, and in other characters; and it is possible that an examination of additional material may show it to be the type of an entirely new group. This point, however, cannot at present be determined. The species is named *Uintacrinus socialis*.

Origin of the Dolomites of the Tyrol.—An important essay on the above subject has been written by Drs. Dölter and Hörnes. It contains a full review of the literature of the subject, with a discussion of the various theories which have been proposed to explain the existence of the great strata of dolomite. The results of an extended chemical examination of the dolomites of the Tyrol by Dr. Dölter are given, embracing a considerable number of analyses. The authors come to the following conclusions, confirming in part the results of some earlier authors :—(1). A large number of extensive strata of limestone, weakly dolomitic, have been deposited immediately through the instrumentality of organic life in the ocean. (2). Some minor occurrences of normal dolomite are due to subsequent metamorphosis, through the introduction of carbonate of magnesia. (3). The larger part of the dolomites, whether more or less rich in magnesia, have been formed from the lime secretions of sea animals through the action of the magnesia salts contained in the sea-water (especially chloride of magnesium). Subsequent local differences have been brought about through circulating waters, dissolving out and concentrating the magnesia at different points.

METEOROLOGY.

Giant Hailstones.—Father Secchi communicated to the French Academy of Sciences (Nov. 27) an account of a remarkable hailstorm observed at Grotta Ferrata. The cloud from which it proceeded was formed with astonishing rapidity, and divided the sky into two nearly equal parts, from N.W. to S.E., advancing and unfolding itself like an immense ball of wool or cotton. The first drops of rain were of extraordinary size, at least a cubic centimeter. The hailstones, which soon followed, weighed from 40 to 60 grammes, and were composed of groups of crystals arranged round a small irregular mass of ice, having almost the appearance of groups of quartz-crystals, mostly with four or five and six faces terminated by a pyramid. Some masses obtained at Marino weighed as much as 300 grammes.

MICROSCOPY.

Diatoms in Wheat-straw.—It will probably be remembered by most of our readers that when our friends Martin Chuzzlewit the younger, and his companion Mark Tapley, located themselves in the highly salubrious city of Eden, they made the acquaintance of a certain enlightened citizen, Mr. Hannibal Chollop, whose opinion of the gentleman who sold them their allotment was expressed in the words "Scadder is a smart man." It would appear that the breed of "smart men" is not yet extinct in the United States, and that in the opinion of the Editor of the "American Journal of Microscopy," and of the Botanical Editor of Silliman's "American Journal," Professor P. B. Wilson, of Washington College, Baltimore, is a very "smart man." The article on the presence of diatoms in wheat-straw, a notice of which appeared in the October number of this Review, seems to have been rather hastily inserted, and on its coming under the notice of the Botanical Editor he wrote "pronouncing the alleged facts intrinsically absurd," but stated his belief that the author of the article had "honestly but ignorantly fallen" into a mistake, a charitable view which he has since seen occasion to alter. The editor of the "American Journal of Microscopy" is far more plain-spoken. He says: "A single glance at the engraving," of the forms of diatoms found in Col. Kunkel's straw, "is sufficient to convince any microscopist that Professor P. B. Wilson never saw 'upon the field of his microscope,' under the circumstances which he has described, the objects which he has delineated." In support of this statement he adduces two cases as follows:—"Bearing in mind," he says, "that these organisms, as figured, have been obtained by destroying the organic matter with nitric acid, we find *Bacillaria* figured as it exists only in the living condition, the frustules being joined together in the peculiar way which has given to this form the specific name *paradoxa*!!! For this diatom to have passed through a bath of nitric acid, and come out in the condition figured, would have been almost as great a miracle as the passing of Shadrach, Meshech and Abednego unscathed through the fiery furnace of Nebuchadnezzar. So, too, we find a *calcareous* foraminifer figured under the same circumstances! Verily, this *is* such a view as has

not 'fallen to the lot' of ordinary microscopists to behold, either in twenty or in four times twenty years." For the signification of these miraculous circumstances we are referred to the following passage in Professor Wilson's paper:—"The result of these investigations shows the necessity of finely divided silica in the soil, so minute as to be capable of passing with facility through the sap cells; secondly, that simple or compound silicates are useless as fertilizing agents, either natural or artificially prepared," which, as interpreted by his critic, means "*If you want to raise good crops, buy our finely divided silica.*"

The Spermatozoa of Amphiuma.—These have been examined by Dr. C. Johnston, who has contributed a paper on the subject to the "Monthly Microscopical Journal" (August, 1876). He says that "several matters of interest were observed—the structure of the spermatic particles, the dimensions of their parts, and the length of the filaments. The total length of each spermatozoon was $\frac{1}{83}$ of an inch. It begins at the moderately acute point of an elongated conical head $\frac{1}{312}$ of an inch in length by $\frac{1}{8128}$ of an inch in thickness; behind which the body, slightly more attenuate, ended almost into the vague. The 'head' presented a small curve; but the body lay straight at times, or else threw itself into serpentine flexuosities. A Tolles' recent $\frac{1}{10}$ immersion objective, with that maker's $\frac{1}{2}$-inch ocular, displayed many new points. The head, highly refractive and firmer than the other part, appeared to consist of a lamina of homogeneous substance bent along its axis, the two tumid edges of which met on the ventral side. Anteriorly these edges were suddenly bevelled away, and were lost by continuity in a delicate filament ending in a faint swelling. Posteriorly the edges contracted at the junction with the body, but were seen to be continuous with two cords which had the same relation as their originals in the head. They lay close together, and from them sprang the dorsal arch, along the ridge of which the propelling membrane was attached. This delicate film extended like a ruffle from the posterior extremity of the head as far as the caudal point; the main part was, however, invisible, but not so the margin, which was bordered with a thickened hem. In a dry preparation the spermatozoids and their details were somewhat deformed, distorted, and spread out; still the characteristics of Amphiuma's seminal particles were very manifest when studied with a fine objective. Thus the edges of the cephalic folds and the somatic cords assumed a beaded appearance, as did also the collapsed arch-fold of the back along its margin. Yet the eye was not satisfied with the dried potential male elements, and reverted with continually renewed pleasure to the moving zooids."

MINERALOGY.

New Vanadium Minerals.—Professor Roscoe has lately described ("Proc. Roy. Soc."). a new mineral containing vanadium, under the name of *Mottramite*, in allusion to one of the localities from which it has been obtained. It forms a crystalline incrustation not more than $\frac{1}{8}$ to $\frac{1}{8}$ inch in thickness, but usually much thinner, coating Keuper sandstone. Occasionally it occurs

in minute velvety black crystals, appearing yellow by transmitted light. It is also met with compact, opaque, and purplish brown. Its lustre is resinous; its streak yellow; H. = 3; sp. gr. 5·894. The analysis leads to the formula $(PbCu)_3Vn_2O_8 + 2H_2(PbCu)O_2$, in this respect analogous to erinite and dihydrite.

Professor Roscoe has also made an examination of Roscoelite (see "Pop. Sci. Rev." Oct. 1876, p. 431), and his analysis leads him to ascribe to it quite a different constitution from that given by Dr. Geuth.

PHYSICS.

Law of Refraction.—Professor Foster, at a recent meeting of the Physical Society, exhibited and described an instrument for illustrating the law of refraction. It is founded on the well-known method of determining the direction of the ray after refraction, by means of two circles described from the point of incidence as a centre, the ratio of whose radii is the index of refraction. If the incident ray be projected to meet the inner circle, and through the point of intersection a vertical line be drawn, the line drawn from the point of incidence to the point where this meets the outer circle is the direction after refraction. This principle is applied in making a self-adjusting apparatus as follows:—A rod representing the incident ray is pivoted at the point of incidence, and projects to a point about four inches beyond. To its extremity is attached a vertical rod, which slides through a nut in another rod, also pivoted at the point of incidence. The lower extremity of the vertical rod is attached to a link, so fixed as to constrain it to remain vertical. By this means the two rods always represent respectively the incident and refracted rays, and the index of refraction can be varied by altering the position of the nut through which the vertical rod passes, on the rod to which it is attached.

PHYSIOLOGY.

Vaso-motor Centres in the Cortex Cerebri.—MM. Eulenburg and Landois ("Centralblatt für die med. Wiss.," April 1876) have, according to the "Academy," discovered that the destruction of certain limited portions of the cortical substance in one hemisphere is followed by relaxation of the arterioles in the limbs on the opposite side of the body. This vaso-motor paralysis causes a rise of temperature amounting in some cases to 5°–7° C. in others to 1½°–2° C. only, and lasting from one day to several weeks. Stimulation of the same portions of the cortex by induced currents is followed by a slight and transient depression of temperature in the opposite extremities (·2° to ·6° C). The associated musculo-motor disturbances showed that these thermic or vaso-motor centres are situated in close proximity to the corresponding motor centres of the limbs. A successful attempt was made to differentiate the vaso-motor centre of the fore from that of the hind leg the former was found to lie a little to the front and to the outer side of the latter.

ZOOLOGY.

A Peripatus from New Zealand.—In the "Annals of Natural History" for November, Capt. Hutton describes a species of the curious genus of terrestrial worms, established by Lansdowne Guilding for a West Indian species under the name of *Peripatus.* Other species have been found in Chili and at the Cape of Good Hope, and hence Capt. Hutton believes the genus to be a relic of the fauna of that Antarctic Continent which, he thinks, existed during the Upper Jurassic and Lower Cretaceous periods. Its characters are very singular, apparently combining the peculiarities of the Myriopoda and the Annelida; it has a soft body and ringed legs and antennæ, but in internal structure it most nearly approaches the Annelida. The New Zealand species (*Peripatus Novæ-Zealandiæ*) is said to be hermaphrodite, which the others are not. Respiration is effected by tracheæ which contain irregular fibres. Capt. Hutton describes the New Zealand species as living among decayed wood, under stones, and crevices of rock. It is nocturnal and predaceous, and secures its prey, sometimes at all events, by shooting out from the oral papillæ a viscid fluid, by which flies and other insects are fastened down. It moves slowly with the body much extended and the antennæ constantly moving about as feelers. The reproduction is viviparous, and seems to go on all the year round, although the animals are half torpid in winter.

Gigantic Cuttlefish.—Professor Verrill ("American Journal," Sept. 1876), states that the organ described by him as the odontophore of the great *Architeuthis* from Newfoundland, is merely a specialized portion of the lining of the mouth or pharynx, covered with sharp chitinous teeth and granules, and that its original position is doubtful. The true odontophore is about three inches long and half an inch wide in its broadest part; the teeth are in seven rows, amber-coloured, and like those of *Loligo* and *Ommastrephes* in form. Professor Verrill also records the discovery, by Mr. Dall, of gigantic Cephalopods on the coast of Alaska. The specimens observed were thrown up on the beach, and the largest was fourteen feet in total length, but even then the extremities of the tentacular arms were wanting. The length of the body to the root of the arms was 102 inches, the arms measured from 30 to 40 inches, the slender portion of the tentacular arms was 61 inches in length, the width across the fins was 42 inches, and the diameter of the body 18 inches. From the characters of the animals, and especially from that of the few remaining suckers, the species is regarded as probably a true *Ommastrephes*, and it has been appropriately named by Mr. Dall *O. robustus.*

A Carpet Eater.—The beetles of the genus *Anthrenus* are well-known destroyers of furs, skins, and similar articles, in fact one of them was named by Linnæus *Anthrenus musæorum*, on account of the ravages committed by its larvæ in natural history collections. An American species, *Anthrenus lepidus*, Leconte, hitherto known as an inhabitant of the Western States, seems to have a special predilection for carpets, and has advanced eastwards so rapidly as to have now attained central New York, where, according to a notice in the "American Journal of Microscopy," it is known as the "Californian Carpet Moth."

A new Fish-parasite.—Under the name of *Taphrobia pilchardi*, Professor Cornalia describes* a curious parasite obtained by him from a pilchard brought to the fish-market at Nice. It is a crustacean, evidently nearly related to *Lernæonema*, but destitute of the long neck characteristic of that genus, the species of which have been found on Clupeoid fishes on our coasts, the long neck and horned-head of *Lernæonema* being represented in the new parasite by a sort of sucker, supported on a short neck, and placed on the lower surface of the body, at about one-third of its length from the anterior end. The body is nearly cylindrical in form, rather more than half an inch long, slightly narrowed and rounded off in front, and divided into three small lobes behind; from beneath these lobes spring a pair of straight egg-tubes, about two inches in length, and resembling in general character those of *Lernæonema.* The skin of the body is leathery, white and opaque, and the whole of the body, except the apical lobes, is buried in a sort of gallery in the side of the fish, in such a position that the anterior extremity with its sucking cup reaches the gills, from which the parasite apparently draws its nourishment. The two long egg-tubes, springing from the hinder extremity of the animal float freely in the water at the side of the fish. The resemblance of the parasite to *Lernæonema* is so close that it may be worth while for such of our readers as reside where pilchards are caught to watch for the occurrence upon them of the characteristic filamentous egg-tubes, so as to obtain confirmation of this curious form, which the describer regards, with some reason, as resembling at once the Lernæans and Peltogasters.

Entomology à la Mark Twain.—The following wonderful description is from the "Lacrosse Democrat." It is in some parts graphic and forcible, but, on the whole, perhaps the stiffest scientific language would be quite as intelligible. The writer had been engaged in a reconnoissance of parts of Southern Minnesota and Southern Iowa to ascertain how far the prospects for next year's crops were affected by the grasshoppers which have been for years such a pest to the Western farmers. The eggs, he found had been laid in abundance, and he remarks that as "the process by which grasshoppers deposit their eggs may be interesting to those who have never been out West to grow up with the country," he will kindly "impart the information that has cost so much labour and research." And this is how he does it. "The eggs," he says, "are found about an inch below the surface of the ground. The eggs are laid by the female hopper. When she feels as though she wanted to lighten her burden she stands upon her narrative like a dog, and begins to dig a hole with her north end. She works patiently until she has a hole in the ground about the size of a lead pencil, an inch or so deep. The hole is so near the subsequent end of the hopper that should you take her by the nape of the neck to pull her out of the hole, she would break in the middle before she would let go. After the hole is all ready the grasshopper spits on her hands and lays down her burden, which consists of material for a sack, which contains from thirty to seventy-five eggs. She covers up the hole and comes out looking as if she had been run through a clothes wringer, and with an appetite that would shame a free lunch fiend, and she attacks anything that the he-grasshopper has left in the

* "Atti Soc. Ital. Sci. Nat.," August 1875.

neighbourhood to eat." In his description of the adolescence of the young grasshopper the writer rather gives the rein to his imagination. He says: "After a few hours fooling around on the ground, the young grasshopper gets on a bush or a stalk, hangs on by his feet, and his wings begin to unfold, and in ten minutes he is ready to fly, when he goes up in the air, winks at the farmer with one eye, and goes to harvesting, without money and without price." A volume of "Episodes of Insect-life" in this highly popular style would probably be a considerable success.

The Zoology of the Caspian Sea.—The zoology of the Caspian Sea has recently been studied by Mr. Oscar Grimm, with important results. He has found in this great salt lake 120 animal species, and states that the whole number existing there must exceed 150 species. His discoveries include 6 new species of fish (a *Gobius* and five *Benthophili*), 20 species of mollusks, (*Rissoa dimidiata, Hydrobia caspia, H. spica, H. stagnalis* with two varieties, *Eulima conus, Neritina liturata, Lithoglyphus caspius, Bythinia Eichwaldi, Planorbis Eichwaldi*, sp. n., *Cardium edule* and var. *rusticum, C. caspium, C. crassum, C. trigonoides, Adacna vitrea, A. edentula, A. plicata, A. læviuscula, Dreissena polymorpha, D. caspia, D. rostriformis*, and some other terrestrial and fluviatile mollusca), a Bryozoan (*Bowerbankia densa* Farre, in which the colonial nervous system may be admirably seen), and about 35 species of Crustacea, among which we find the family Gammaridæ in particular represented by colossal forms and *Idothea entomon* in considerable quantities. Then there are 20 species of worms (*Sabellides octocirrata*), numerous Turbellaria, two Sponges (*Reniera flava*, sp. n., or perhaps a variety of *R. alba*, O. Schm., and another *Reniera* in the larval state), and, lastly, 13 Protozoa, among which are 6 new species.

Remarkable Structure of Young Fishes.—Dr. Günther, of the British Museum, has recently discovered that the young of the sword-fishes and *Chætodons* are in structure exceedingly different from the adults. In the young *Chætodon* the front of the body is shielded with large bony plates, in one species produced into three long, equidistant horns, which diverge ray-like from the body. In the sword-fishes the scapular arch is prolonged into a horn at the lower part, and the ventral fins are wanting. There is no sword, but the jaws are long, of equal length, and both are furnished with teeth. As the fish grows, the scapular horn disappears, the ventral fins grow, and the upper jaw is developed in excess of the lower. The long teeth disappear, and the upper jaw grows into the toothless, sword-like weapon which gives the fish its peculiar character.

Change of Skin in Menopoma.—Mr. A. R. Grote has observed the change of skin in that curious North American Batrachian, *Menopoma alleghaniense.* The wide mouth of the animal was opened several times to its fullest stretch, by which means the skin was parted on the lips and then rolled backward over the head. The whole cuticle was previously separated from the surface of the body, forming a sort of transparent veil, and the *Menopoma* soon withdrew its front legs from their old skin by a series of jerking moments. Then the animal moving forward, the whole pellicle was swept back by the resistance of the water until it was folded against the hind legs. The *Menopoma* then turned sharply round, and, taking the skin in its mouth, drew it over the hind legs and tail. The skin was held in the mouth for a time and finally swallowed. ("Silliman's Journal," Dec. 1876.)

EVIDENCES OF THE AGE OF ICE.

By HENRY WOODWARD, F.R.S., F.G.S., &c.

[PLATE III.]

ONLY a few years ago it was looked upon as an article of faith among geologists that the whole globe was once in a molten, incandescent state, and that the conditions of temperature now prevailing on the surface of the earth had been produced in process of time by the slow and gradual cooling of the once fused and glowing mass. But whatever may be the unknown heat of the deeper strata, that of the surface results solely from the great source of heat, the centre of attraction of our planetary system—the sun.

The oscillations between heat and cold that we experience from day to night, and from summer to winter, all depend on the laws of absorption and radiation of heat given off by the sun to the earth, or radiated by the earth into stellar space.

If the earth were a globe of perfect regularity, presenting on its surface no contrast of land and sea, plateaux and plains, snow and verdure, a nearly equable distribution of climates would be established over its whole extent, and one could exactly measure the degrees of heat by those of latitude.

But such we know is not the case. Every place has its own climate. Such variations depend on the elevation of the land above the sea; the position of a place, whether inland or on the coast; the direction and height of its mountain chains: the extent of its forests, savannahs, and cultivated lands; on the width of its valleys, the abundance of its rivers, the outline of its coast; on marine currents, prevalent winds, clouds, rain, fogs, &c.; these varied causes constitute, together with the latitude, what is called "the climate of a country." *

Undoubtedly the most important climatal phenomenon is that of temperature, for to heat we probably owe all the movements of the atmosphere which we call winds. Parts of the

* Elisée Reclus, "La Terre."

earth become overheated, and these put in motion the whole system of atmospheric currents; these too give to the winds the moisture destined to be dispersed as clouds, and to fall again on the earth as snow and rain.

The impulse to all these movements of air and water is given by the sun's rays; and on this luminous body all the life of our planet depends. To the facts, then, that the earth is so uneven in its surface configuration, that its land and water are so very irregularly distributed, and that it receives an unequal share of solar heat varying with the seasons and the latitudes, we owe that infinite variety of climate by which it is characterized.

One country near the polar circle receives more warmth than does another situated at a less distance from the tropics; one region of the temperate zone is hot in comparison with certain spaces in the equatorial zone. And in each place the temperature continually varies and oscillates under the action of winds, currents, and all the other agencies which affect climate; and when indicated by lines on the surface of the earth, an inextricable network is formed, of which we can only recognize the principal traits.

Fifty years ago Humboldt first conceived the idea of uniting by lines all those parts of the earth's surface having the same annual average temperature.

These imaginary lines traced on the circumference of the globe are called isothermal lines; they give the thermal latitude, which differs widely from the geometrical latitude.

While the lines of degrees traced every 69½ miles apart are parallel to the equator and perfectly regular, the isothermals are contorted into numerous and often sharp curves over all parts of the earth.

The thermal equator (or the curve of the greatest average heat, on each side of which the temperature gradually decreases towards the poles), lies almost entirely in the northern hemisphere, which is warmer than the southern.

The district of greatest heat lies between 10° and 60° E. longitude, and between 15° and 30° N. latitude; that is to say, it is the area to the east and west of the Red Sea, and embracing the greater part of that narrow gulf, and also that of Persia.

The district of greatest cold lies between 120° and 140° E. longitude, and between 60° and 80° N. latitude, along the course of the river Lena, the principal river of Siberia, covered during many months of the year by snow and ice; within the frozen mud and ice-cliffs at whose mouth have been found the entire carcasses of the mammoth and the woolly rhinoceros.

All these sinuosities of the isothermal lines over the earth's surface are caused by similar isolated areas of a higher or lower temperature, which deflect them in a greater or less degree from a straight course.

Thus in the southern hemisphere, where the continents are diminished gradually towards the south, and where the moderating influence of the ocean tends to eliminate all climatic differences, the lines of equal annual temperature seem to be pretty regular, and in the Antarctic Ocean they may be considered parallel to the degrees of latitude. The most marked curves of these southern isothermals are developed immediately to the west of Africa and the west of South America, where the influence of the currents of cold water flowing towards the equator from the Antarctic Ocean is most visibly demonstrable.

In the northern hemisphere the sinuosities of the isothermal lines are much more marked than in the southern, and cut the degrees of latitude at all angles. One of the highest of these isothermal waves is that which rises in latitude 45° N., off the coast of Halifax, Nova Scotia, passes to the south of Newfoundland, ascends in a north-easterly direction past the south-east coast of Iceland, attaining its summit about latitude 65° N.; it then bends down to Drontheim, Stockholm, and Moscow, falling again nearly to latitude 45° N. in Central Asia.

But whatever may be the sinuosities of the lines of equal temperature, they all indicate a more or less rapid decrease of heat between the equator and the two polar zones.

In the interior of continents, the chief modifications of climate are produced by mountain ranges and winds; on coasts and islands the climate depends on ocean currents and winds.

Happily for England, we enjoy here what is called an "insular climate." There are special reasons why the climate of the British Isles is so much milder than that of any other place in the same latitude, and we may with advantage consider these exceptional circumstances before proceeding further. Take, for example, two parallels of latitude at the present day. Off Little Belle Isle, in the month of July 1864, Mr. J. F. Campbell * records the temperature of the air at 48°, water 40° (wind south when the temperature was taken), and icebergs in sight. Mr. Campbell passed bergs 400 ft. deep and 200 ft. long, and many others of far larger size, some being 150 ft. above the water. Belle Isle is in the same latitude as London.

In 1831, Mr. Redfield states that the harbour of St. John's, Newfoundland, was completely blocked by ice so late as the month of June. This is 2° further south than the port of Liverpool, and yet one never heard of the port of Liverpool being blocked by ice, even in January! Again, the limit of constantly frozen ground which extends to the southern border of Hudson's Bay (where ice is found in digging wells in summer, at a depth of 4 ft. below the surface) is in the same latitude

* In his "Short American Tramp," p. 66.

as London. Nairn, on the desolate and frozen coast of Labrador, is in the same latitude as Dublin; yet the former has only a mean temperature of 28°, whilst Dublin has a mean temperature of 49°, or nearly double the warmth of Nairn. The cause of this great disparity in the relative temperature of places lying in the same parallels of latitude is to be found in the prevalence of certain winds and oceanic currents, which cause the isothermal line to bend northwards so many degrees in passing from west to east.

The ocean-current in which we are especially interested is that mighty stream which issues from the Gulf of Mexico, flows in a north-easterly course across the Atlantic, and is commonly known as the "Gulf-Stream."

Since 1842, when the energetic Captain Maury, of the United States Navy, first drew the attention of the American Government to the importance of preparing "wind and current charts," the Gulf-Stream has not wanted observers and historians. This remarkable oceanic current is about 25 miles in breadth off Cape Florida, and it increases to 127 miles off Sandy Hook, whilst its depth diminishes from 1,000 to 200 ft. and under as it proceeds northwards. From the American Coast and from the banks of Newfoundland it is deflected across the Atlantic, reaching the Azores in about 78 days, after flowing nearly 3,000 miles. Our own islands enjoy a portion of its warmth; and even Spitzbergen, in latitude 79° north, feels its influence, and before its warm breath the glaciers are stopped abruptly in their descent to the sea.

Mr. Croll has estimated the total quantity of water conveyed by the Gulf-Stream to be equal to that of a current of water 50 miles broad and 1,000 ft. in depth, flowing at the rate of 4 miles an hour, with a mean temperature of 65°. Before its return from its northern journey, he concludes it has cooled down at least 25°. Each cubic foot of water, therefore, has carried from the tropics upwards of 1,500 units of heat, or 1,158,000 foot-pounds.* Principal J. D. Forbes has calculated that the quantity of heat thrown into the Atlantic Ocean by the Gulf-Stream on a winter's day would be sufficient to raise the temperature of the air which rests on France and Great Britain from the freezing point to summer heat.

At the very time the Gulf-Stream is rushing in greatest volume through the Straits of Florida, and hastening to the north, a cold counter-current is descending from Baffin's Bay

* According to the above estimate of the size and velocity of the stream, 5,575,680,000,000 cubic feet of water are conveyed every hour by the Gulf-Stream, or 133,816,320,000,000 cubic feet per day. The calculations of Sir John Herschel and Captain Maury make the amount still greater.

by Davis Straits to the south with almost equal velocity. This current flows inshore on the North American seaboard, and also beneath the Gulf-Stream, but does not mingle with its waters.

The Gulf-Stream is, of course, only one of many oceanic currents, but to us it has a pre-eminent degree of interest. It brings us genial showers, borne by the south-westerly winds, from the surface of its warm and steaming waters. It carries the temperature of summer even in the depths of winter as far north as the Great Banks of Newfoundland, and there maintains it in the midst of the severest frosts. It is the presence of this warm water and a cold atmosphere in juxtaposition which gives rise to the "silver-fogs" of Newfoundland, one of the most beautiful phenomena to be seen anywhere in the domains of the Frost King. Every west wind that blows crosses this stream on its way to Europe, and carries with it a portion of this heat to temper the inclemency of the northern winter. It is the influence of this stream upon the climate that makes Erin the "Emerald Isle," that clothes the shores of Albion in evergreen robes, and encourages the myrtle and magnolia to flourish at Mount Edgecombe in the open air all the year; it carries West Indian seeds to the Scottish isles, wafts the floating pteropod-shells to the latitude of Iceland, and renders the fauna of Spitzbergen richer than that of any other Arctic realm.

But all earthly advantages are transient, and not even the Gulf-Stream can be expected to be always so partial to us as it is to-day. Indeed, geologists are aware that formerly, owing to the subsidence of that narrow belt of land, the Isthmus of Panama, at one time, and probably by the subsidence of the Mississippi Valley at another, the Gulf-Stream has more than once been diverted from our coasts, and our islands were, as far as they were above water, glaciated even as the coasts of Labrador are at the present day.

Let us briefly consider the evidences on which geologists have relied in writing this latest chapter in the geological history of our island. These evidences are most abundant and varied; some of them, indeed, lie close to our own doors, and may easily be studied and examined. I allude to the great series of deposits known to geologists as "glacial deposits," and which have resulted either from the action of glaciers or icebergs, or some modification of them. These may be classified as follows:—

I.—1. Roches moutonnées.	**II.—5. Erratic blocks.**
2. Striated rock-surfaces.	**6. 'Kames,' 'eskers,' and sandy gravelly drift.**
3. Boulder-clay and 'till.'	**7. Stratified clays with arctic shells.**
4. Moraines of valley glaciers.	

In some instances these can be divided into—

I. Those due to glaciers and coast-ice, whilst the land was greatly elevated (1 to 4).

II. Those due to the sea and icebergs whilst the land was greatly depressed (5, 6).

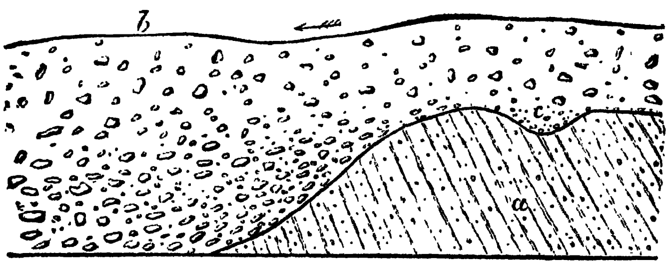
But many of them are so altered and reconstructed that it is exceedingly difficult to attribute them to one or other of these divisions. What evidences, then, have we to-day?

"The general surface of a great part of the British Islands," says Mr. James Geikie, "excluding the centre and south of England, has a smoothed contour, which is now generally recognized as the work of land-ice.

"Hills, valleys, and knolls of rock have been ground down and have received that characteristic flowing outline which ice alone, of all natural agencies, can produce (*roches moutonnées*). When, moreover, we strip off the superficial cover of detritus and examine the surface of rock underneath, we find it covered with the well-known grooving and striation such as are met with by the side of every modern glacier in the Alps.

"These markings are not disposed at random, but run in more or less parallel lines. And when we examine them over the

FIG. 1.



SECTION AT EAST END OF NEIDPATH TUNNEL, PEEBLES.

a, Silurian rocks; *b*, till, showing arrangement of stones on the lee side of the rock; *c*, gravel in a hollow under the till. The arrow indicates the direction in which the till has travelled.

length and breadth of the country, we discover that they point away outwards in every direction from the main masses of high ground, indicating that the ice which produced them covered the land in a deep continuous sheet, like that of Greenland, and that it moved outward and downward from the high grounds to the sea. So vast was the mass of ice that it swept over considerable hills, smoothing and striating their sides and summits."*

To this period Professor Ramsay refers the general erosion of the present lake-basins of Britain.

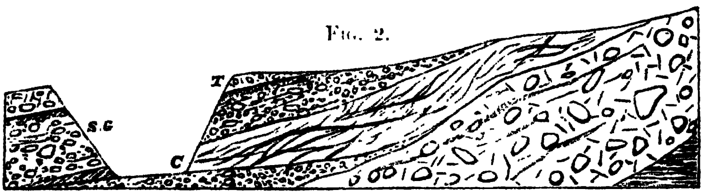
* Geikie, "Great Ice Age."

Another feature of the surface-geology of the country dates from the same period—the widely-distributed boulder-clay, or "till." This deposit is not at all likely to be confounded with any other. It consists of a mass of unstratified clay, with blocks and boulders of stone stuck into it promiscuously, the whole seeming to be the result of an irregular "pell-mell" carrying forward and deposition of the materials (see figs. 1 and 2).

The colour and general composition of the mass may vary according to the nature of the rocks from which it has been derived. Thus, in a region of dark Carboniferous shales the boulder clay is leaden, grey, or black; in one of Old Red, or Triassic sandstones, it is red. In the Chalk country it is quite full of bits of chalk, and is hence called the "chalky boulder clay."

The stones in the clay range in size from mere grains of sand up to masses a yard or more in length. Wherever the rock of

FIG. 2.



SECTION OF GLACIAL DEPOSITS IN THE SETTLE AND CARLISLE RAILWAY CUTTING AT CULGAITH.*

T, upper till; *S G*, sand and gravel; *C*, laminated clay; *T'*, lower till; *R*, rock
Length, 40 feet.

which they consist has been of a kind to receive and retain surface markings, the stones are found to be covered with ruts and striæ, which run for the most part in the direction of the long axis of each stone.

There can hardly be any doubt that these markings have been produced under a sheet of land-ice similar to that which covers the whole interior of Greenland at the present day.

This great inland ice-sheet, that at places advances to the coast and thrusts the snouts of its glaciers into the sea itself, giving rise to enormous icebergs, covers the entire continent of Greenland save a few dozen miles at most of coastline, which remain free. It forms on its seaward face precipitous cliffs of ice about 200 feet high, covered with a thin layer of earth and stones, but rises at first rapidly, afterwards more slowly, to a height of several thousand feet. During Professor Nordenskiöld's expedition to Greenland in 1870, he made an excursion upon this inland ice-sheet with one companion, Dr. Berggen,

* We are indebted for the loan of this block to the Council of the Geological Society.

and two Greenlanders.* They penetrated thirty miles into the interior in four days, attaining an altitude of 2,200 feet above the level of the sea.

No moraine-matter was observed on the surface of the ice; but everywhere, under the influence of the sun's rays, this immense ice-field was in motion internally, and large rivers and lakes on its surface descended through the ice in roaring torrents, by "swallow-holes" 2,000 feet deep, to join the streams which flowed beneath.

The ice-sheet which some geologists believe to have been once co-extensive with our island, covering it from its sea-level to the highest peak of its loftiest mountains in Wales or Scotland, was, it is assumed, only a repetition of the present state of Greenland, or, on a larger scale, of what one may see taking place to-day on the Alps and the Himalayas and other mountain ranges, whose heads are covered by perennial snows. For the process of reduction of temperature takes place in a corresponding ratio, whether we sail to the North Pole with the *Alert* and *Discovery*, or with Professor Tyndall scale the heights of the Matterhorn or Monte Rosa.

If, then, temperature decreases with altitude above the sea-level, an elevation of our island would produce the same effect upon it as if we could transport it bodily to the latitude of Greenland!

It is well to keep these facts clearly before the mind, because, among the numerous explanations offered by our leading geologists, this question of the *relative elevation* above the sea-level has not had that prominence given to it in the discussion which it deserves. The results of *altitude* have in fact been confounded with those of *latitude*.

The stones that occur in the boulder-clay spread over so many counties in England differ widely in character; and, from a study of these, it is possible to determine the direction in which the ice-sheet moved, and the centres of dispersion whence the boulders were derived.

Wherever the surface of the rock is of sufficient hardness it is everywhere polished, rounded, and striated in a precisely similar manner to what is seen to be taking place in valleys occupied by glaciers at the present day; whilst the boulder-clay is the finely comminuted particles worn down to powder, like the grains of wheat into flour, by the glacial millstone, and poured out in a turbid stream, or pushed along as a great rampart of stones and rubbish forming the terminal moraine, as we see it at the foot of the Mer de Glace, above Chamounix, or, at times,

* The Greenlanders turned back after two days, but Nordenskiöld and his companion pushed on two days' journey further.

as in Greenland, pushed into the sea itself, for in Lancashire this deposit is associated with fragments of marine shells.

Where this is the case, the finer particles have been carried away and re-assorted by sea-currents and mixed with marine organisms, as in the Clyde glacial beds; the shells indicating arctic conditions.

During one period of the glacial epoch we had a great depression of the land; to such an extent, indeed, that these glacial deposits, associated with marine shells identical with species now existing, have been found in Cheshire up to a height of 1,200 feet. On Moel Tryfaen, near the Menai Straits, fifty-seven species of shells of marine mollusca have been obtained (all indicative of a colder climate than that of our present sea) at a height of 1,300 feet above the sea.

It was at this period, no doubt, that icebergs and floes of ice laden with boulders and other foreign material were transported from the western and northern highlands and dropped their burdens, on melting, over and about where London now stands, especially in the neighbourhood of Finchley and Muswell Hill, where vast numbers of erratic blocks have been observed, and numbers of transported fossils have been collected by the late Mr. N. T. Wetherell, F.G.S., and other geologists.

Various theories have been brought forward in explanation of the glacial epoch. Among these that of Mr. James Croll, F.R.S., of the Scottish Branch of the Geological Survey (also adopted in the main by Mr. James Geikie, F.R.S.), has been largely advocated. It is based on the calculation that at certain unequal periods, owing to the eccentricity of our earth's orbit around the sun, the earth is occasionally somewhat further distant from the sun than at the present time (98,500,000 miles, instead of as at present, 90,500,000; or, to be exact, 8,641,876 miles more distant). The last occasion Mr. Croll puts at 200,000 years ago.

The other cosmical cause advocated by Mr. Croll is the slight variation in the polar obliquity of our earth, which varies through long periods between $23\frac{1}{2}°$ and $24\frac{1}{2}°$.

When the earth, from these two causes combined, became subject to a slight variation in its two hemispheres, which would give to one $7\frac{1}{2}$ days more of the sun's presence in one tropic than the other now enjoys, then Mr. Croll concludes the ice on the more favoured pole would melt, and that on the less favoured would increase; and this cause alternating, would give rise at long intervals to alternate glacial epochs in each hemisphere, accompanied by displacements of the earth's centre of gravity, and a rising of the waters of the sea combined with an increase of ice at the pole.*

* See Mr. Croll's paper on the Glacial Epoch, "Geol. Mag.," 1874, p. 348.

Mr. James Geikie, in his book on "The Great Ice Age," actually makes two glacial epochs with an interglacial period between them, into which period he introduces—1st, a milder cold temperate climate, with the mammoth, the woolly-coated rhinoceros for denizens of our forests, and the great bear dwelling in our caves, the winters still severe. 2nd, a warmer subtropical climate, with the retreat of the arctic mammalia northwards, and the advance from the south of the hippopotamus, the cave-lion, the hyæna, and palæolithic man, evidenced by the rude flint implements found in valley gravels.

Then followed another cold period, before which the southern mammalia disappeared, and were again succeeded by arctic animals. Even these, however, migrated southward, leaving the land to be again overspread with ice and snow.

Mr. Geikie admits that there were not unfrequent shiftings in the distribution of land and sea, but these do not seem to him to have been the chief causes of these climatal changes. After this second cold period, Mr. Geikie next introduces the submergence of the British Islands to 2,000 feet; gives it a final refrigeration, in which period the drifts and angular erratic blocks were scattered over the South of England, and over North Germany and Russia, and the Swiss glaciers were augmented. Then Britain for the last time—

Arose from out the azure main.

to be again re-forested and re-peopled, this time by the moose-deer and the cariboo or reindeer, the arctic fox, the lemming, and the marmot; and Neolithic man became the denizen of our caves and woods, and made pictures of the animals he there saw and hunted.

The only considerable change which Mr. Geikie proposes to introduce at this period is the severance of our island from the continent, and the complete insulation of Britain.

I hope it may be possible to simplify this chapter of our Glacial epoch, and here I am glad to say I have the high authority of Professor Nordenskiöld, who has visited both Spitzbergen and Greenland more than once, that from the evidence of fossils obtained in a succession of beds in arctic latitudes, he is led to the conclusion that there has not been in past geological times a periodical alternation of warm and cold climates on the surface of the earth.

In Eocene Tertiary times sub-tropical conditions prevailed in the latitudes of London and Paris, and both plants and animals betokened a temperature at least as high as that of North Africa.

Since that period, through Miocene and Pliocene formations, we are able to trace a gradual lowering of the temperature of

our islands by the more temperate sub-arctic and arctic character of their faunas, and what traces remain of their floras also.

Then came the Glacial period, first initiated perhaps by the diversion of the Gulf-Stream, caused by the subsidence of the Isthmus of Panama, or more probably by the opening up of a course for its waters up the great central valley of North America, down which the Mississippi river now flows, and which, save a narrow strip between Lake Superior and Hudson's Bay, is nowhere more than 800 feet above the level of the sea: this, if lowered, would give a direct course for the Gulf-Stream up to the north-west coast of Greenland and to Smith's Sound.

Afterwards, by the elevation of the land only 600 feet, this island would be united to the continent on the one hand, and to Ireland on the other; whilst its shores would extend outwards to the margin of the plateau of Ireland, seventy miles to the west, and from beyond the Shetlands in the north to near the north-west of Spain in the south.

Probably the elevation was far greater, for the British Isles have a powerful line of volcanic disturbance running down about the meridian of 6° west longitude, which in the western Highlands and the north of Ireland was active down to an exceedingly late geological period (Miocene).

If it be necessary to call in extra-mundane causes to explain the great increase of ice at this glacial period, I would prefer the theory propounded by Dr. Robert Hooke, in 1688; since by Sir Richard Phillips and others; and lastly by Mr. Thomas Belt, C.E., F.G.S.; namely, a slight increase in the present obliquity of the ecliptic—a proposal in perfect accord with other known astronomical facts, and the introduction of which involves no disturbance of that harmony which is essential to our cosmical condition as a unit in the great solar system.*

Such an increase in the obliquity of our earth's axis would result in an increase of ice, not at one pole at a time, as proposed by Mr Croll, but at both poles simultaneously; a condition which accords with the fact that with our present obliquity we have ice at both poles now; the larger supply at the antarctic being purely caused by the fact that in the southern hemisphere we have a polar continent surrounded by a circumpolar ocean (fig. 4), whereas in the arctic we have a polar sea surrounded by circumpolar land (fig. 3).

* In Jupiter the axis is nearly perpendicular to the plane of its orbit. In Saturn the obliquity is 29°. In Mars it is 30¼°; in Venus it reaches the extreme of 75°, so that its tropics actually overlap its arctic circle, and there are no temperate zones. The earth has an inclination of 23½°. It is estimated that its axis may have been inclined as much as 35½° during the glacial period.

The ocean is the great evaporating dish, the continent the condenser; hence the larger glaciers of the southern pole, where the ice-wall of the land ice, which in Greenland stops some miles inland, here comes down into the sea itself (Pl. III.), ploughing up the sea bed, and spreading out its terminal moraine in the ocean.

What length of time has elapsed since the Glacial epoch occurred we cannot pretend to say; Mr. Belt estimates the date to have been 20,000 years since, Mr. Croll 200,000 years ago. We may therefore, I think, rest content with the geological evidences of a modification of the climate afforded by the re-

FIG. 3.

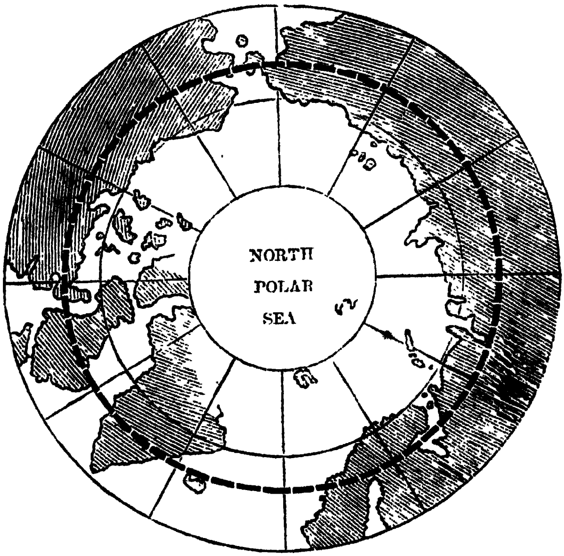


DIAGRAM OF NORTH POLAR SEA.

A marine area almost surrounded by land. To contrast with Fig. 4, the South Pole having a land surface entirely surrounded by ocean.

mains of glaciers and icebergs and the zoological evidence of a former change in the distribution of the mammalia telling the same story.

I believe the musk-sheep and the mammoth were both præ- and post-glacial animals, and that the mammoth survived till after the climate became milder, but that he was a scarce animal from that time. The musk-sheep lives on still in Arctic North America.* The sabre-toothed lion (*Machairodus*) is so rare

* See the beautiful specimen lately presented to the British Museum by Capt. Feilden, the naturalist on board H.M.S. *Discovery*, and now on exhibition in the Zoological Gallery.

with us, as a fossil, that we may fairly assume he belonged to the earlier præglacial cave period, as did the panther, lion, lynx, hippopotamus, two species of rhinoceros, and one variety of mammoth (*Elephas antiquus*).

If the Esquimaux of Greenland live on the borders of the ice-fields, and many animals flourish there also, and birds are most abundant, it is fair to assume that, on the retreat of the ice, man and animals advanced and occupied all the fertile valleys and pursued the chase as the Lapps, Finns, Tungusians, Samoiedes,

FIG. 4.

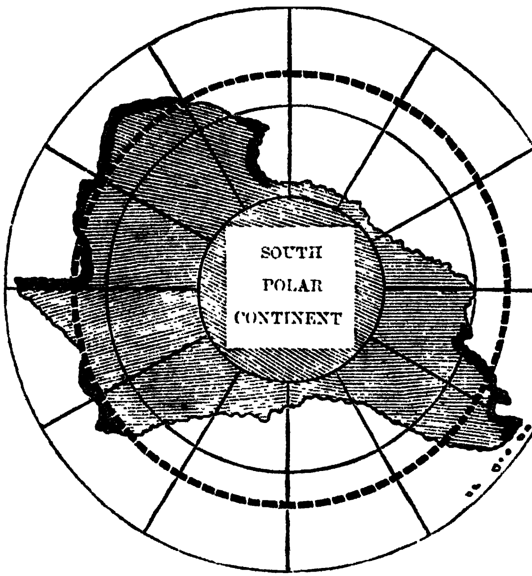


DIAGRAM OF THE SOUTH POLAR CONTINENT.

To illustrate the vast land area forming the gathering ground for the great Antarctic icebergs. The darker parts along the margins of the South Polar land indicate those portions which have been actually coasted along, such as South Victoria Land (with Mounts "Erebus" and "Terror"), Enderby Land, Trinity Land, &c.

American Indians, and Esquimaux have done in our times further north.

We speak of the stable land; but we must always remember that, whether the land is upheaved by volcanic energy from beneath, or the sea-level lowered by the abstraction of water and the piling up of snow and ice on the circumpolar lands, the effect is the same to man as an observer. This however we know, that in the latest geological period—the Tertiary (both Miocene and Pliocene) early man may have been a witness of some of the

largest exhibitions of elevatory force on our earth's surface; for in these later periods the great Himalayan, Persian, Carpathian, and Alpine chains have been upraised, carrying high upon their flanks, as a part of their structure, beds of Nummulitic limestone of Middle Eocene age!

If, then, the Himalayas with Mount Everest have been raised up to 29,000 feet above the sea in this recent period, our islands may well have oscillated a few hundreds of feet; and trivial as such phenomena may be when compared to the elevation of the great backbone of the Asiatic Continent, nevertheless these lesser changes have for us an interest which even the lofty mountain masses do not possess. Nor is it an idle question to ask—"Was man present to witness these modifications of our islands?" He may have been, judging by his implements. Certainly in France and Switzerland he saw and killed the musk-sheep; and in France he also saw the mammoth alive and pictured him. But the reindeer and the horse were the chief objects of the chase, as their remains testify. Nor is it at all improbable that these nomadic cave-dwellers are represented to-day by the tribes of the Arctic seaboard, who have retreated with the amelioration of the climate which compelled the reindeer to go further north to give place to more southern animals and hunters, and these in time to civilized man himself.

MINERAL CAVITIES AND THEIR CONTENTS.

By W. N. HARTLEY, F.R.S.E.,
KING'S COLLEGE, LONDON.

"THERE are few enquiries in natural science more calculated to awaken curiosity than those relating to the changes which the matter composing the surface of the globe has undergone. The imagination is excited by the magnitude of the operations, by the obscurity of the phenomena, and the remoteness of the time at which they occurred; and all the intellectual powers are required to be brought into activity to find facts or analogies, or to institute experiments by which they may be referred to 'known causes.'"

The foregoing passage was written by Sir Humphry Davy, when President of the Royal Society, in the year 1822, and it was certainly never more full of truth than at the present day, notwithstanding the advances in physics, chemistry, and geology which have since been made.

It formed the preface to a paper on the aqueous and gaseous contents of the fluid-cavities of minerals. These cavities, which are most commonly found of large size in rock crystal, were relieved of their contents by boring holes in them with a diamond, the specimens being submerged in mercury or in water. Wires were inserted to displace the gases, and capillary tubes to draw off the liquid, much in the same way that vaccine matter is drawn off from a vesicle. The liquid was found to be in almost every case either pure water or some dilute saline solution containing a sulphate or a chloride of sodium or potassium. The gaseous portion was nitrogen, generally in a rarefied condition, but having in one case a tension equal to ten times that of the atmosphere. It was undoubtedly proved that the brown viscid liquid in one crystal was mineral naphtha.

Sir David Brewster, in the following year, announced the discovery of a remarkable liquid—or, as he then said, two liquids

—in the cavities of topazes, in rock crystal, and in chryso-beryls. He was led to the investigation by reason of the violent explosion of a topaz which he was heating in order to observe its change of colour. He also became acquainted with the fact that a Mr. Sanderson, a jeweller in Edinburgh, placed a topaz in his mouth, upon which it exploded with great violence, the fragments inflicting a wound. Under the title of "Explosive Gems," a note occurs in Brewster's "Natural Magic" giving an account of his researches.

In the year 1860 Mr. Alexander Bryson, of Edinburgh, having made a microscopic examination of rock sections during the previous ten years, published a note on the formation of granite. Fluid-cavities were noticed in many specimens, the gas-bubbles in which disappeared when warmed on a hot stage to 35° C. (97° F.), and returned on cooling to 29° (84°·2 F.), the liquid undergoing at the same time a sort of boiling movement. This apparent ebullition had previously been noticed likewise by Brewster. Not knowing the nature of the liquid, Bryson concluded that granite was crystallised from aqueous solutions at a temperature not exceeding 29° C. (84°·2 F.) He remarked the same liquid in hexagonal prisms of quartz, in porphyry from Dun Dhu in the Isle of Arran, in the schorl of Aberdeen granite, and also in the trap tufa of the Calton Hill, the basalt of Samson's Ribs, and in greenstone from the Crags in the Queen's Park, Edinburgh.

There is a particular line of research which bears on these liquids. First of all the experiments of the Count Cagniard de la Tour, who, in the year 1822, showed the possibility of converting a liquid into vapour, in spite of any high pressure it may be subjected to, if only the temperature be sufficiently high. The most successful experiments in sealed glass tubes were made with ether, and, when the liquid occupied even as much as half the capacity of the tube, it ceased to be a liquid at a temperature of 150° C. (302° F.) Experiments with water similarly conducted always resulted in a disruption of the tube, most probably because of the solvent action of water upon the glass at high temperatures. In order to overcome this difficulty Cagniard de la Tour made use of a gun-barrel, closed completely by an accurately fitting screw plug. At the upper part of the tube was placed a marble, and when the lower end, containing water, had been heated to about the temperature of melted zinc, it was found that the marble on shaking rattled when it fell against the lower end. There was nothing within to "break its fall," as there otherwise would have been if the tube had contained a liquid. When the tube had cooled the conditions were altered, and the water itself could be heard. This remarkably ingenious and striking experiment proved the possibility of converting even water entirely into vapour despite

an enormous pressure. The reasoning is of course applicable to all liquids. The presence of air was no obstacle to such change; it only rendered the dilatation of the liquid more regular, and the more easily observed in glass tubes up to the moment when it vanished completely.

Although Guyton de Morveau, towards the end of the last century, had liquefied ammonia gas by exposure to a temperature of −48° C. (−54°·4 F.), and Monge and Clonet had liquefied sulphurous acid, yet their results appeared so incredible that doubt was cast upon them, on the supposition that the gases were not sufficiently dry. Northmore, in 1805–6, liquefied hydrochloric acid, sulphurous acid, and chlorine by pressure, but in such a manner that they were not obtained in a pure state. It is, therefore, to Faraday that we owe our first and most trustworthy information on the liquefaction of gases. His first paper appeared in 1823, and the second more complete publication in 1844. In this latter, when describing the properties of liquid carbonic acid, he says: "I am inclined to think that at about 90° F. Cagniard de la Tour's state comes on." In other words, he believed that at the temperature of 90° F. (32°·2 C.) the carbonic acid enclosed in sealed tubes ceased to be a liquid, and was resolved into a vapour.

Mr. George Gore, of Birmingham, has examined the solvent powers of many liquefied gases, and these are not at all such as one would expect. Thus the immiscibility of carbonic acid with water, and its power of dissolving iodine with a violet colour like that of the solution made with bisulphide of carbon, have been shown. Liquefied hydrochloric acid loses the chemical activity its aqueous solution possesses; for instance, it does not redden litmus paper, and it is quite inert in contact with a powerful base like caustic lime.

The next point is the knowledge which Thilorier gave us concerning the properties of the liquid carbonic acid. He prepared it in large quantities and daringly sealed it up in glass tubes in a state of perfect purity; in this way he was enabled to ascertain its tension at different temperatures, and its rate of expansion.

Now Simmler in 1858, offering an interpretation of Brewster's observations, pointed out that the new liquid, in some cases at least, was most probably liquefied carbonic acid. The most remarkable physical property of this liquid of Brewster's was its enormous expansibility by heat, and on comparing Thilorier's co-efficient of expansion for this liquid with that which Brewster estimated for the expansion of the liquid in crystals, he found them to be almost identical. This comparison was accomplished, however, in a much more satisfactory manner, in 1869, by Messrs. Sorby and Butler, who published conjointly an

account of their researches on the structure of rubies, sapphires, diamonds, and other minerals. The rate of expansion of the liquid contents of an unusually large cavity in a sapphire between the temperatures of 0° and 30° C. (or 32° and 86° F.) was measured and compared with that of liquid carbonic acid as determined by Thilorier, between these two temperatures. It was found to agree so closely with the surprising dilatability of carbonic acid, that they had no hesitation in concluding that any difference might be due to an error in one of the thermometers.

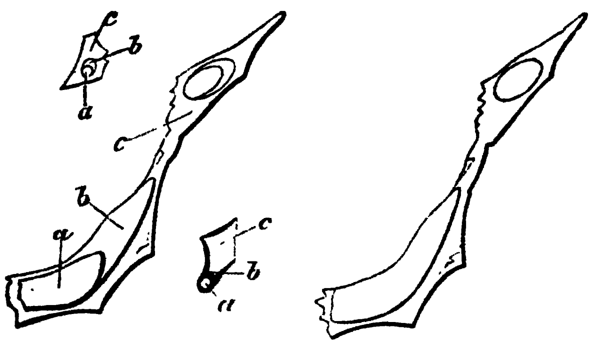
Mr. Sorby found that 100 volumes of the liquid in the sapphire expanded to 150 volumes at 30° C. (86°·F.), to 174 volumes at 31° C. (87°·8 F.), and to 217 volumes at 32° C. (89°·6 F.), something quite unapproachable by any other substance, even a gas.

In the same year, 1869, Vogelsang and Geissler, of Bonn, published an account of experiments made on rock crystal, in which the former observer had noticed a liquid floating upon water enclosed in cavities. They crushed the quartz under baryta-water and found that the latter became turbid, owing to the formation of carbonate of baryta, and they measured the rate of expansion of the liquid as nearly as the shape of the cavities admitted of this being done. Their most remarkable experiments, however, were performed in the following manner:—Taking a small retort containing a mineral in fragments, it was attached to a tube commonly known as a Geissler vacuum-tube. There were platinum wires sealed in at each end of the tube, and to one end was affixed an ordinary Sprengel pump. After a vacuum had been produced so that an electric spark would no longer pass across from wire to wire, the fragments of the mineral were heated, the mineral decrepitated, because the cavities exploded, and the spark passed through, because the previously vacuous space then contained a gas. This gas, when examined by the spectroscope, declared itself to be carbonic acid.

To Professor Andrews, of Belfast, we are indebted for extraordinary additions to our knowledge of the gaseous and liquid states of matter. He has established the fact that there is no gap between these two conditions; a liquid may pass by a gradual change of properties into a gas. It expands and becomes excessively mobile; the boundary between gas and liquid is less and less easily recognized, until it finally disappears. When the reverse change occurs, the gas becomes more and more compressible, a wavering and flickering movement is visible, a line of demarcation appears, and this, as the liquid contracts, becomes more and more distinct. These changes were observed in very strong glass tubes of small bore, which being filled with carbonic

acid, were screwed on to a reservoir of mercury. Compression of the gas within the tubes was accomplished by the action of a screw upon the mercury; the joints of the apparatus, being rendered tight by greased leather washers and cobbler's wax, were capable of sustaining a pressure equal to 500 atmospheres for days together. At no temperature above 30°·92 C. (87°·6 F.) was it found possible to maintain the liquid condition of carbonic acid, no matter what the pressure might be. This temperature is called by Professor Andrews the "Critical Point" of carbonic acid, and the condition of the substance is that mentioned by Faraday as "Cagniard de la Tour's state." Each gas and liquid has a fixed and definite temperature for its Critical Point, and this, in such gases as hydrogen, nitrogen, and oxygen, is below the reach of

FIG. 1, FIG. 2.



A CAVITY IN ROCK CRYSTAL CONTAINING CARBONIC ACID[1]
× 46 *diameters.*

Fig. 1.—*a* is gaseous carbonic acid; *b* is liquid carbonic acid; *c* is water. These letters also apply to the smaller cavities.

Fig. 2.—The specimen warmed to 31° C.; the line of demarcation between gas and liquid has disappeared. The water is seen undisturbed.

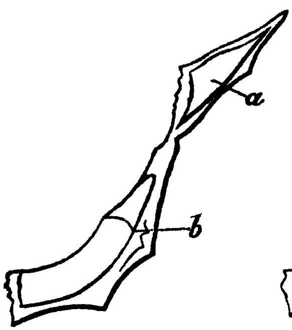
any refrigerative apparatus at present known to us; hence any pressure we may put upon them will fail to cause liquefaction.

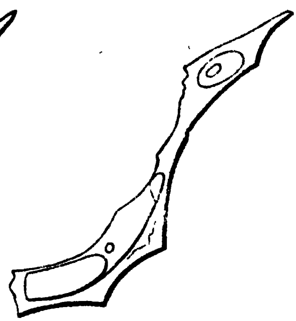
Professor Andrews last summer lectured to the Fellows of the Chemical Society on the methods of research which are peculiarly his own. He completely charmed his audience by his easy conversational manner and by the way he took one into his confidence, explaining all his difficulties and how he overcame them. Anything of the kind more delightful has seldom been heard. Every one shared his enthusiasm.

[1] Figs. 1, 2, 3, 4, 8, 9 and 10 are reproduced from the "Journal of the Chemical Society," by permission of the Council.

In 1872 the writer bought a section of rock crystal containing fluid-cavities, with the object of submitting these to Cagniard de la Tour's experiment and watching the effect under the microscope, as it was thought that rock crystal would be proof against the corroding action of water. On warming the specimen gently over a lamp, it was found that a cavity previously seen to contain a liquid was apparently empty. Carefully watching the cavity under the microscope, the replacement of the liquid was noticed. Bearing in mind the experience of Professor Andrews, it seemed desirable to know at what temperature the liquid disappeared, for it was most probable that it had attained its critical point. The simplest mode of operating appeared to consist in immersing the

FIG. 3. FIG. 4.





A CAVITY IN ROCK CRYSTAL CONTAINING CARBONIC ACID
× 46 *diameters.*

Fig. 3.—*a* shows the shape of the cavity at its upper end when the water is driven out into the lower part. At *b* is seen the faint line indicating the surface of the liquid carbonic acid, as seen when warm. It should be compared with Fig. 1.

Fig. 4 simply shows how the liquid can be driven from the lower to the upper end of the cavity, or *vice versâ*, by a heated wire.

These drawings are from the microscope, and therefore must be inverted to get their true position.

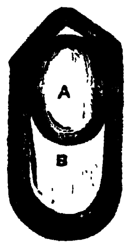
slide in water of known temperature, removing, wiping it hastily, placing it on the microscope stage, and instantly examining it. A number of experiments showed that the liquid disappeared at 30°·8 C. to 30°·9 C., and returned instantly at any lower temperature. Here was most convincing evidence that the liquid was carbonic acid. The adjoining woodcuts (figs. 1–4) will convey to the eye of the reader the general aspect of this cavity.

The fact mainly regarded of interest in connection with this specimen was that the liquid never expanded by heat; thus

it differs from that in cavities examined by any previous observer.

The following observation of Thilorier explains the reason :—"When a tube containing liquid carbonic acid is one-third full, at 0° C., it constitutes a *retrograde thermometer*, in which increase of temperature is shown by diminished volume, consequent on the vaporization of the liquid, and *vice versâ*; while if the tube be two-thirds full, a *normal thermometer* of great sensitiveness is the result, the liquid expanding by heat in this case" ("Ann. Chim. Phys." [2], lx. 249).

FIG. 5.



CAVITY IN TOPAZ at 18° C. × 70 *diam*

Heat expands the liquid. A, gaseous carbonic acid. B, liquid carbonic acid.

It will be seen that in the cavity the proportion of liquid to gas resembles that in a retrograde thermometer, and furthermore the approach of a warm wire causes the liquid gradually to diminish. Especially rapid is this action as the critical point is approached, and at the same time the line of demarcation between liquid and gas gets fainter, and it loses its curvature. (See fig. 3.)

There was also noticed a faint flickering shadow in the point of the cavity when the liquid was about to condense. This is doubtless an effect corresponding to the striæ noticed by Professor Andrews. The liquid carbonic acid was always found floating on water if this latter substance happened to

FIG. 6.

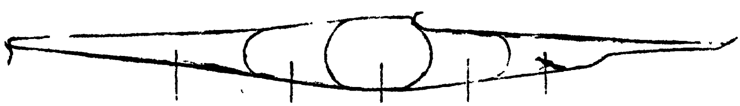
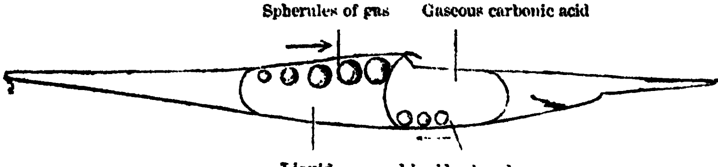


FIG. 7.



LIQUID CAVITY IN TOURMALINE × 250 *diameters*.

be present, and this is quite in accordance with the specific gravity as estimated by Thilorier, which at 0° C. is 0·83 and at 30° C. is 0·6.

A cavity of quite a different description is that found in a topaz (fig. 5). It contains only a trace of water, and is at ordinary temperatures filled to the extent of two-thirds its capacity by liquid carbonic acid. Rise of temperature expands this liquid until it entirely fills up the space occupied by gas, after which expansion the critical point is very easily

FIG. 8.

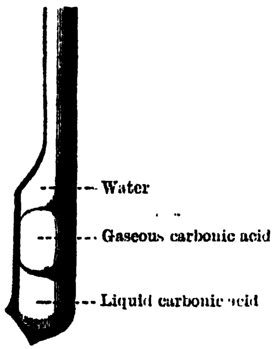
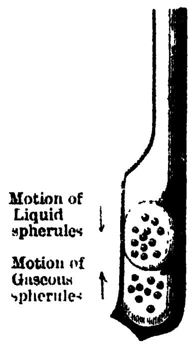


FIG. 9.

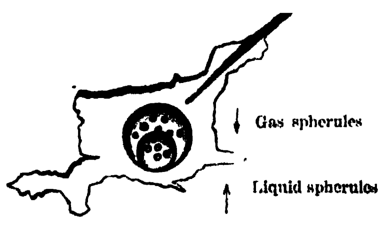


A CAVITY IN A TOPAZ.

Fig. 8 shows the proportions of liquid and gaseous carbonic acid and water.
Fig. 9 shows the boiling motion when it has nearly terminated.

attained. A very curious appearance, resembling ebullition, follows as the gas returns to liquid, the explanation of which is as follows:—When the gas is chilled, a sort of mist forms throughout the space; the individual spherules of this mist grow so large that they begin to touch each other, to coalesce, and to gravitate. They of course at the same time entangle gas, and as

FIG. 10.



A CAVITY IN ROCK CRYSTAL.

they descend to the lower part of the cavity the spherules of gas (bubbles) take an opposite direction; consequently when a portion of the liquid has collected at the lower end and gas at the upper, there are showers of liquid descending into, and streams of bubbles rising out of the liquid. In two or three

seconds the movements have ceased. This ebullition is illustrated by a drawing of a cavity in another topaz, which contains at ordinary temperatures about equal volumes of water, gaseous carbonic acid, and liquid carbonic acid (figs. 8 and 9). A similar cavity as to its contents, but being exceedingly shallow, and having the bubbles within it much flattened, is that existing in a tourmaline (figs. 6 and 7). The drawing, fig. 10, represents a cavity seen in a specimen of quartz; the contents are undergoing apparent boiling. The conditions favouring this singular mode of condensation seem to be, first, that the greater part of the carbonic acid shall be in the liquefied state at ordinary temperatures, so that the liquid expands greatly on approaching the critical point; secondly, that the cooling shall be sudden. This seeming ebullition is the only test which as a general rule is significant of the liquid having passed its critical point, for we cannot tell after the substance has expanded so as to entirely fill the cavity, whether it be in the gaseous or the liquid state.

The following table shows several variations noticed in the critical point of carbonic acid existing in various minerals:—

	Critical point.
Topaz	28° C. = 82°·4 F.
Topaz	28° and 26°·5 C. = 82°·4 F. and 79°·7 F.
Topaz	27°·55 C. = 81°·5 F.
Tourmaline . . .	27°·27 C.
Tourmaline . . .	26°·9 C.
Sapphire	between 30°·5 and 31° C.
Sapphire	between 25°·5 and 26° C.
Sapphire	29°·5 C. = 85°·1 F.
Rock crystal . . .	30°·95 C. } = 87°·71 F.
Rock crystal . . .	30°·95 C. }
Rock crystal . . .	32°·5 C. = 90°·5 F.
Rock crystal . . .	33°·7 C.
Rock crystal . . .	29° C. = 84°·2 F.
Rock crystal . . .	30°·95 C.
Beryl	30°·92 C. = 87°·6 F.
Rock crystal . . .	21° C. = 69°·8 F.

It is noticeable that in the sapphires, topazes, and tourmalines the critical point is lowered a few degrees, while in one specimen of rock crystal the temperature is nearly 10° C. or 18° F. below what it should be. Fortunately, Professor Andrews has shown that the critical point undergoes such a change when traces of any incondensable gas are present. Carbonic acid containing 15 per cent. by volume of nitrogen has a critical point of about 21° C., and it is not at all unlikely that this is the gas here present, since Sir Humphry Davy detected it in the fluid-cavities

of quartz, and it frequently escapes in a pure state from mineral springs and fissures in the earth's crust.

A great number of rock sections, chiefly porphyries, granites, and basalts, have been examined for liquid carbonic acid, in but few cases, however, with success.

In making these observations it is necessary to get rid of the influence of the mineral causing double refraction, by fixing a Nicol's prism on to the microscope stage; otherwise in small water cavities the appearances are very similar to those seen when two liquids are present, so that one may be easily deceived.

An exceedingly useful little contrivance for applying heat to the specimens of crystals containing fluid-cavities, consists of a glass tube about $\frac{3}{8}$ of an inch in diameter and 12 inches long; it is drawn out at one end to a jet of about $\frac{1}{16}$ of an inch aperture, the jet being bent at an obtuse angle at about an inch from the point. To prevent the glass being softened and bending when heated, it is covered for four inches in its central part by a piece of brass tube, which just slides on not too easily. The straight end of the tube is somewhat pointed, and passes through an india-rubber cork fitting into a universal joint upon a stand having a sliding motion in the upright, so that it may be raised and lowered at will. The end of the glass tube which passes through the cork has a piece of india-rubber tube slipped over it, 15 inches in length, and connected with a ball-syringe, whereby air may be drawn in and discharged again. By heating the metal tube with a spirit-lamp or Bunsen burner, the air discharged by squeezing the ball-syringe will be heated, and may be directed on to the object while under the microscope without any displacement.

Mr. P. J. Butler has employed a somewhat similar apparatus, but of more elaborate construction, for showing the evaporation and condensation of carbonic acid in some of his large specimens. The usefulness of this little instrument will be readily understood when it is mentioned that portions of liquid carbonic acid, so small as not to be recognizable under a magnifying power of 800 diameters, have been revealed by its aid. They could not have been greater than the $\frac{1}{50000}$ of an inch in diameter, and their presence was made known by the instantaneous change in the appearance of the cavities caused by warm air, and then again a reversion to their former appearance by subsequent cooling.

Let us consider what would be the effect of an enormous pressure of rock on carbonic acid heated above its critical temperature: it would be in a condition, as far as we can tell at present, capable of unlimited compression, so that, taking into consideration the comparative incompressibility of water, it would be possible to convert it into a gas with a greater density

than that of water. For instance, at 63°·7 C. (145°·4 F.) under a pressure of 223 atmospheres, the gas has been reduced to $\frac{1}{447}$ of its volume (Andrews, 'On the Physical Properties of Matter,' &c., Proc. Roy. Soc., 1875). Under these circumstances it must be a gas at least as dense, if not denser than water.

Certain specimens of rock crystal containing bubbles of carbonic acid and also other gases floating on water have been heated under mercury to such a temperature that the relative densities of the gas and the water were reversed, and the bubbles sank. In one specimen this change took place at 150° C. (302° F.) It is an effect caused by the expansion of the water, and the consequent compression of the gas in the bubble.

The diamond, which is the densest form of carbon, has never been artificially prepared, and its probable mode of formation has never been satisfactorily explained. It has been supposed to be derived from organic matter by a process of dehydrogenation, the hydrogen being separated from the carbon by the action of moist peroxide of iron and sulphates. A view which is equally tenable is that carbon is separated from carbonic acid, in a very highly compressed condition, by a process of deoxidation, accomplished by alkaline sulphides, metallic iron, or protoxide of iron at moderately high temperatures, or by the mutual reaction of hydrocarbons and highly compressed carbonic acid, which would result in the separation of water and condensed carbon. The combined actions of high temperatures and pressures are conditions under which no chemical reactions have ever been made in the laboratory. To imitate the supposed operations of nature is difficult, because, setting aside the factor time, chemical reactions in the bowels of the earth are reactions carried on under tremendous pressures in sealed tubes of vast thickness.

ARE THE DESMIDS AND DIATOMS SIMPLE CELLS?

By G. C. WALLICH, M.D., Surgeon-Major, Retired List, H.M. Indian Army.

NONE but those who have had long practical experience in microscopical analysis can form an adequate conception of the perplexing difficulties which are inherent in this kind of research. In ordinary investigations connected with natural history, the object to be pronounced upon may be inspected, handled, and tested in every possible way, by any number of persons possessed of average vision and the requisite scientific education, without much risk of their disagreement as to its visible characters. But, unfortunately, a new set of conditions comes into operation when the microscope has to be consulted. To some extent the instrument becomes an arbiter in the matter, and not always a very safe one. Then, it is not merely a good eye, but a good objective,—not merely the requisite scientific knowledge, but the requisite degree of manipulative skill, coupled with the careful training that alone qualifies the observer to distinguish between appearances that are real and those that are spurious and dependent altogether on the methods of examination employed—which have one and all to be secured before trustworthy results can be achieved; whilst the student who happens to be engaged in investigating the minute structure of the lowest organic forms is often confronted at the outset by the additional annoyance of being unable to reconcile what he actually sees in the microscope with what teachers and text-books have taught him that he ought to see. This last-named difficulty is nowhere so strikingly manifest as in studying the structure of these lower forms by the light of the commonly accepted definition of the term "a vegetable cell."

Now it is a singular fact that, although the cell theory undoubtedly constitutes the basis of all histology, and was itself originally propounded with reference to the lowest animal and vegetable types, when brought to bear specially on these very types, it not only breaks down but forces on us the conclusion

that the "primordial simplicity," which has been so constantly referred to as constituting their invariable characteristic, is altogether imaginary. Primordial simplicity may be an essential element in the doctrine of evolution; but such a necessity does not warrant its assumption, as if it were an already demonstrated fact. We know that complex vital processes are carried on even in the lowest types of being. But because we neither know nor are able to conceive *how* they are carried on, we are not justified in taking for granted that what appears to us, even with our most refined appliances, to consist of a mere particle of structureless jelly, must necessarily be as primordially simple as it appears.

I propose on the present occasion to show that the Desmidiaceæ and Diatomaceæ—well known as these two beautiful groups of organisms are wherever the microscope is employed—are not such simple structures as they are represented to be; and that in this respect they furnish a conspicuous example of the danger of attaching more weight to preconceived theory than to actual structure as it presents itself when seen under sufficiently favourable conditions. But before entering on the inquiry it is indispensable that we should start with a clear idea of the meaning which usually attaches to the term "vegetable cell" when applied to those lowest forms of plant life in which every individual cell, although constituting an integral part either of a symmetrically grouped series, or of a mere colony, is able to maintain a perfectly independent existence.

According to the commonly accepted definition, as given in a recent standard work of reference, such a cell is "a closed sac or vesicle, composed of an *originally* imperforate membrane formed of the substance called cellulose, this membrane enclosing fluid contents so long as the cell retains its vitality"; the word "originally" being obviously inserted in the definition with a view to meet the cases, constantly occurring amongst the higher orders of plants, in which the cell wall is more or less perforate. We are further told that this closed sac or vesicle is of sufficient strength to protect its fluid or semifluid contents; and that it is formed of two quite distinct layers, the innermost of which (the "Primordial Utricle" of Mohl) is identical in composition with the general protoplasmic substance of the organism; whereas the outer layer differs from that substance not only in containing no nitrogen and being closely allied in chemical composition to starch,* but also in not taking part in any of the vital processes which are carried on within the structure.

* As a matter of fact the difference here spoken of is not so great as is represented, inasmuch as starch, in the shape of *dextrine*, is found in the protoplasmic contents.

A good idea may be formed of the appearance of the simpler kind of vegetable cell by an examination of *Protococcus* or *Palmella*, both of these organisms being exceedingly common and obtainable at almost any season of the year. In *Palmella*, as will be seen on reference to the annexed woodcut, fig. 1, the cells are surrounded by an externally investing gelatinous layer, *a*, of which no mention is made in the definition, owing to its being regarded as a mere occasional and supplementary appendage. This view, however, appears to me to be insufficiently established, inasmuch as there is reason to believe that it is present in the unicellular algæ generally, though often in such an extremely attenuated state as to be invisible even with the aid of the highest powers of the microscope; and the evidence of its existence is in these cases derived altogether from analogy and

FIG. 1.



The three figures A, B, and C, represent specimens of *Palmella* before division, after division into two, and these two, after subdivision into four distinct individual cells. The small letters indicate the same parts in each case—*a*, the external jelly-like matrix; *b*, the "primordial utricle" of Mohl; *c*, the cellulose wall; and *d*, the coloured and granular endochrome. It will be seen that the gelatinous investiture does not participate in the division.

observed phenomena in the organisms which are inexplicable on any other supposition than that some external investiture is present. But, apart from the question of its invariable presence, it becomes a matter of great importance to determine whether the gelatinous substance continues, so long as the parent structure lives, to participate in its vitality, or whether it ought to be regarded as effete and dead.* It is so perfectly hyaline and amorphous that the microscope fails to reveal in it the slightest trace of structure. And yet amongst the Diatomaceæ it assumes such a variety of characters, and is in some instances endowed with such a marvellous degree of elastic and contractile power, during the lifetime of the parent organism, *but no longer*, as to suggest the inference that it resists decay and disintegration solely through some vital bond between it and the cell contents.

* The case is probably met by regarding it, in accordance with Dr. Beale's view, as "formed material," although not in the sense of its being devoid of a low degree of vitality.

Advancing a step higher, but still confining myself to structures which avowedly come within the definition of "simple cells," we find in *Closterium*, one of the Desmidiaceæ, that at the period when the frond is just matured, the cavity bounded by the cellulose wall is completely filled with protoplasm; and, so long as the frond is uninjured, this protoplasm presents itself in two somewhat different states; the one, which constitutes the true *endochrome* and the bulk of the cell contents, being of an emerald-green colour and minutely granular; * the other amorphous, almost if not wholly devoid of colour, and constituting (according to my interpretation of the appearances) a thin well-defined but *free* layer between the true cell that surrounds the coloured endochrome and the immediate inner surface of the cellulose or mere protective covering. It is at this point that my interpretation of cell structure (so far as these lowest plant types are concerned) diverges materially from that which has been arrived at by other observers. For whilst it has been customary to regard the surface film of colourless protoplasm as a membrane, or *quasi*-membrane, and to assign it a position, in the normal condition of the organism, immediately in contact with the inner surface of the cellulose wall, I am now prepared to show that, in the Desmidiaceæ, the only portion of the general protoplasmic substance that can with truth be said to constitute either a membranous or *quasi*-membranous investing film does not form part and parcel of the colourless protoplasm, but of the coloured protoplasm or endochrome, by which it is secreted in the shape of a closely investing boundary wall. And, reasoning on this fact as distinctly noticeable in *Closterium*, and other elongate species of the Desmidiaceæ, and on actual observation as regards the changes that take place from time to time within the so-formed cell, it seems legitimate to assume that the colourless protoplasm is solely concerned in the processes of development that go on *exteriorly* to its surface, whilst the true endochrome is solely concerned in the inauguration and establishment of the processes connected with the reproduction and multiplication of the organism which take place within it.

It is true that some writers who have given a great deal of close attention to the subject, altogether deny the existence of any kind of investing membranous structure within the cellulose wall; and describe the portion of the colourless protoplasm, to which the name of "primordial utricle" has been applied, as a "mere pellicle produced by coagulation of the surface of the protoplasm, just as a 'skin' forms over size or other similar

* It is almost superfluous to observe that I abstain from entering into any description of various other minute portions of the structure, solely because these are in nowise connected with the present inquiry.

substances when they dry up in the air." * But, unfortunately, this explanation, although undoubtedly more in consonance with the facts as regards the colourless protoplasm, is based on the assumption that there is no kind of dividing film interiorly to the cellulose wall; and, consequently, that the true endochrome is not separated in any way from the colourless formative layer which is an invariable and most important constituent of the general cell contents.

Again, since distinct apertures are known to exist in the cellulose wall of the Desmid, and the siliceous covering of the Diatom, occurring sometimes as mere minute perforations, sometimes as projecting processes which are distinctly tubular, it is reasonable to conclude that these channels of communication between the exterior and the interior parts serve the purpose of bringing the protoplasmic substance into immediate contact with the medium in which the organisms live, and from which are derived all the materials for their development and growth. And coupling these facts with the indisputable presence, in a large number of the Desmidiaceæ and Diatomaceæ, of a jelly-like secretion, altogether externally to the cellulose and siliceous walls of these organisms, and the difficulty of explaining how this jelly-like secretion is either produced or kept in "working order" otherwise than through being in direct communication with the colourless formative layer through the intervention of the apertures in the protective wall, it appears almost impossible to doubt that the *quasi*-vitality of the gelatinous secretion (or exudation, if this term be preferred) is determinable only by the death of the parent structure.

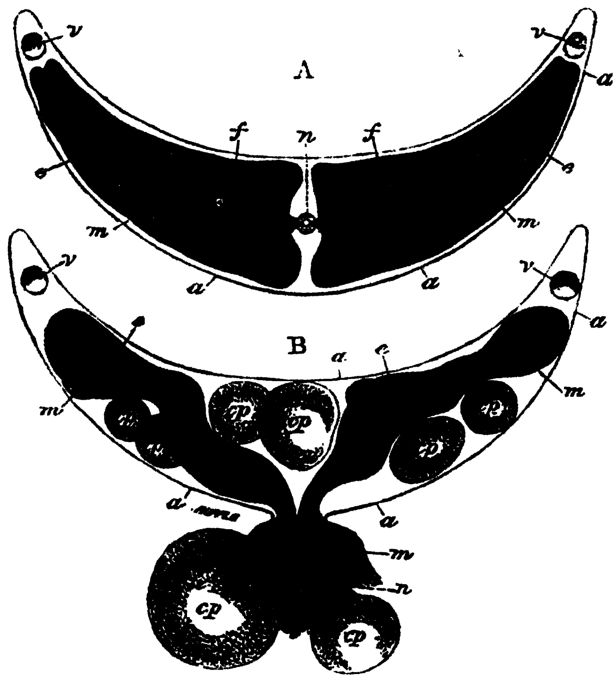
As the evidence furnished by *Closterium* is of a very important kind, it is right to mention that the drawings from which the accompanying figures were copied were made from nature; that no chemical reagents were employed to render the true characters more pronounced, solely in order to avoid the risk of at the same time evoking characters that are factitious; and that the specimen depicted at B, fig. 2, was but one of many similarly crushed, whilst under observation on the stage of the microscope, to show the relation between the cell wall and the several cell contents.

Prior to the application of pressure, the frond (fig. 2, A) presented the following characters. Immediately within the well-defined cellulose wall, *a*, and completely investing its inner surface, was to be seen the thin stratum of amorphous colourless protoplasm, sharply divided on its inner aspect from the masses of brilliant green protoplasm constituting the true endo-

* 'Micrographic Dictionary.' Third Edition, p. 643.

chrome. The *nucleus*, *n*, with its *nucleolus*, occupied a position at the central part of the frond, where the ends of the dark band of endochrome, *f f*, are seen impinging against it; the usual terminal vesicle, *v*, being present near the apex of each horn of the cellulose crescent. The rupture of the frond took place (as it almost invariably does) at the centre of the convex part; and, at this point, its contents slowly exuded into the water on the slide. Simultaneously with this exudation an

FIG. 2.



A. Frond of *Closterium* in which division has already commenced—*a*, cellulose wall; *n*, *nucleus* resting in the midst of the colourless protoplasm; *e*, endochrome; *m*, investing membrane of endochrome; *v v*, vesicles containing vibratile granules; *f f*, "fillets."

B. Crushed frond of a specimen of the same; *a*, cellulose wall; *e*, endochrome now become slightly granular; *c p*, globules of colourless protoplasm; *n*, *nucleus*; *v v*, vesicles.

entering current of water became distinguishable by the minute particles of foreign matter which were carried in along with it; and the amorphous colourless protoplasm at once broke up into a number of subglobular masses (B, *c p*); the periphery of each of which presented just as close a resemblance to a cell-membrane as the periphery of the sinuous, but still unbroken,

masses of coloured endochrome within the cellulose wall. But so long as retained within it, neither did the globular masses of protoplasm coalesce with the darker masses of endochrome, even when so forcibly squeezed together as to flatten each other to a certain extent; nor did these two portions of the contents mix in the least degree with the water that had gained ingress to the interior of the chamber. Up to this stage, therefore, there seemed just as much reason for assuming that both portions had become, as it were, instantaneously invested with a firm pellicle, as that one or both had, previously to the rupture of the cellulose wall, possessed some such investiture. But the moment the two portions escaped through the ruptured wall, it was only the colourless protoplasmic globules that still retained their perfectly defined outline. The endochrome mass which protruded showed perceptibly (by the irregularity of the freed margin, which could be seen amalgamating slowly with such portions of the globules as happened to be in immediate contact with it) the point at which its investing membrane also had become ruptured. Lastly, on the pressure being increased, simultaneously with the further escape of the contents not only did the cellulose wall become folded and puckered, but portions of the yet retained investing membrane of the endochrome could be distinctly seen within it in a similar condition.

It appears evident, therefore, that the colourless protoplasm exists independently of any special investing wall of its own, and behaves in precisely the same way as sarcode; whereas the true endochrome is encased in an imperforate membranous covering of sufficient strength to resist a considerable degree of pressure and distension before it yields and becomes ruptured; and, being more or less granular, is not so viscid.

I shall now proceed to show how far the facts already adduced in reference to the cell formation in the Desmidiaceæ can be said to furnish a key to that which is to be met with in the most nearly allied family, namely, the Diatomaceæ.

The structure of these organisms is undoubtedly more complex in some respects than that of the Desmidiaceæ, notwithstanding that their general physiological characters, the manner in which the processes of multiplication by "binary division," and of reproduction by the fusion of the protoplasmic contents of two or four cells, the formation of a "sporangium," and the evolution from this body of the germs of an entirely new generation, are virtually identical in the two families.*

Thus (speaking generally) we find the endochrome in both

* See a paper on "The Relation between the Development, Reproduction, and Markings of the Diatomaceæ," by the author, "Monthly Microscopic Journal," Feb. 1877, p. 77.

families more or less brilliantly tinted, green in the one, yellow or greenish-yellow in the other, and at times minutely and sparsely granular; the colourless formative protoplasm existing in a free state within the outer wall; a centrally situated nucleus; terminal vesicles; chlorophyll granules, minute granular masses, the office of which is as yet unknown; oil globules; an outer perforate protecting wall; and lastly, in a large number of species, an external gelatinous matrix.

But although there is this close similarity both in structural and physiological characters, when we come to details some conspicuous peculiarities present themselves in the Diatomaceæ, for which there would appear to be no parallel elsewhere. First and foremost amongst these is the substitution of an inorganic for an organic outer covering; that is to say, one composed of silex, instead of cellulose, which, in some form or other, constitutes the protective and sustaining wall of every other vegetable cell; and the composition of the siliceous covering, not of a single continuous piece like the cellulose covering of the Desmidiaceæ, but of several, and in certain genera an indefinite number of, distinct pieces.*

The twin portions of the Diatom frustule, called the "valves," are, I presume, far too well known to require any description at my hands. But I must mention that, although the valves constitute twin members of the protective covering of the organism, so far as their development is concerned, they are entirely distinct from the "intermediate piece" or "connecting zone," which is developed subsequently to the completion and consolidation of the valves, and is sometimes a permanent, sometimes a supplementary and deciduous portion of the structure.† Hence although the general siliceous covering of the Diatom is undoubtedly the homologue of the cellulose covering of the Desmid, the dual composition of the valves, coupled with the also dual composition of the connecting zone, the overlapping pieces of which slide freely and independently one within the other, renders quite untenable the opinion expressed by some writers, that the connecting zone is the silicified portion of the primordial utricle,‡ "left exposed when the valves recede from each other in order to make room for the increase" just referred to. For, admitting for the sake of argument, that the first developed or innermost of the two overlapping pieces of the connecting zone were thus formed, it is obvious that when this is once consolidated the perfect

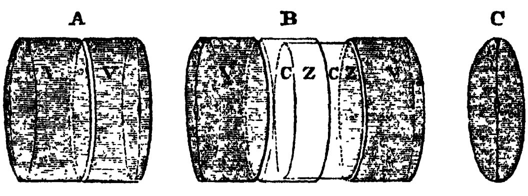
* In "Rhabdonema."

† See paper already referred to.

‡ Of course the term is here used as applying to the superficial layer of protoplasm in immediate contact with the siliceous wall.

rigidity and impermeability of the material would be incompatible with the production, by the same means, of a second independent siliceous layer altogether externally to the first. On the other hand, if we regard the valves and connecting zones as the product of the colourless formative protoplasm which is present not only within the chamber, but sends forth a delicate film to invest exteriorly the already silicified parts (free communication being, as already pointed out, afforded between the contents of the chamber and the surrounding water by means of the apertures in the margins of the valves, and also between the plates of the connecting zones themselves), all difficulty vanishes, and the observed structure of the Diatom frustule becomes forthwith reconcilable with the formative faculty which has, under any view of the case, to be assumed as the agency whereby the mineral secretion is effected. As it is very difficult to make all this clear by mere description, I have endeavoured to give a general idea of the structure of the Diatom frustule, and the relations of the valves and connecting zones to each other, by the subjoined diagram, fig. 3.

FIG. 3.

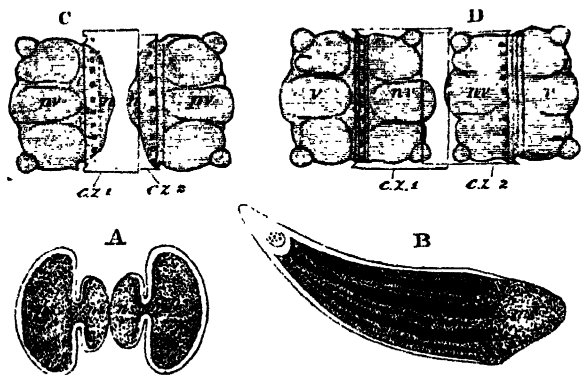


A. Front view of a naviculoid Diatom frustule when just completed, and before division has begun to take place. The central double line represents the two valvular margins; *v v*, the two valves.
B. The same frustule when division is taking place, and the connecting zones *c z*, *c z*, have been formed.
C. Front view of one of the valves of same.

It has already been seen that in the Diatomaceæ, as in the Desmidiaceæ, there exists the same division of the protoplasm into a colourless formative portion, and one more or less brilliantly coloured which constitutes the true endochrome, and contains within its substance the laboratory and materials, so to speak, which are requisite in the processes of division and reproduction. In the just *completed* frond of the Diatom the true endochrome occurs in two halves, each of which is so perfectly distinct in outline as to warrant the conclusion (when coupled with what has been noticed as being the case in the Desmid) that it is in like manner enclosed by an investing wall, although the extreme tenuity of this has heretofore prevented it from being distinguished. But it is well to bear in recollection that in the

Desmid the endochrome of the parent cell constitutes a continuous mass till division takes place, this being the only condition under which the protoplasmic material for the two new valves about to be formed could be exuded from the divided surfaces; for, obviously, no exudation could take place were these surfaces already sealed by the closing in of the membranous investment. But whereas in the Desmid the development of the cellulose covering proceeds simultaneously with the exudation of the young segment, becoming thicker and firmer as

FIG. 4.



A. A frond of a Desmid, namely *Cosmarium*, in which division is about one-third completed. *p s p s*, the two parent segments normally separated by a deep notch; *n s*, *n s*, the two young segments being budded forth from the narrow but open passage *i i*, by which the parent segments were held together like Siamese twins.

B. A segment of a *Closterium*, in which genus the segments part company at a very early period; *a s* being the incipient young segment which is being budded forth as in the last case.

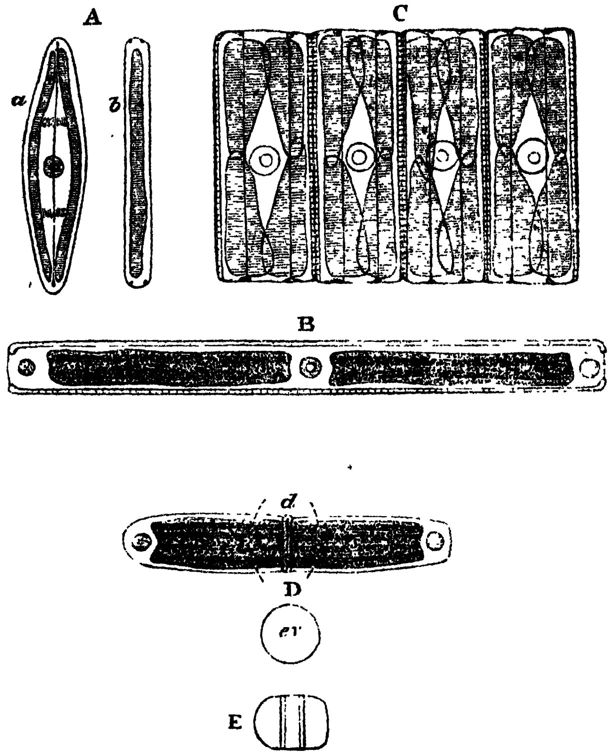
C. A frustule of a Diatom, *Biddulphia*, about half-way advanced in the process of division—*p v*, *p v*, the parent valves; *n n*, the endochrome masses being budded forth, precisely as in the Desmid, from the open surface of the divided cell contents; *c z*, *c z*, the two connecting zones sliding apart, one within the other, telescope fashion, to accommodate themselves to the increasing bulk of the cell contents during division.

D. The same, division being completed, and the two perfect and consolidated siliceous valves, *n v*, *n v*, shown within the still persistent connecting zones which had protected them during their development.

the process advances; in the Diatom the secretion of the siliceous wall does not commence at all until the soft plastic protoplasm of which the new valve is to be formed, has already attained its full proportions and figure. This fact admits of a ready explanation, inasmuch as the unyielding nature of the siliceous coat, however thinly it may be deposited, would effectually bar all further development of the soft parts, were the siliceous deposit to begin at any stage anterior to that above described. (See fig. 4, in which the process of development of the new

segments in the Desmid and the new valves in the Diatom are represented as taking place).

FIG. 5.



A. *a*, front view of a valve of *Navicula*, showing the endochrome arranged in two longitudinal lamellæ along the margins of the valve; *b*, front view of the *frustule*; when dividing, the endochrome here seen will divide longitudinally along its centre.

B. Front view of *frustule* of *Nitzschia*, showing the endochrome in this view as if it consisted of only two portions; the nucleus centrally situated, and the terminal vesicles at the extremities, precisely as in *Closterium* (fig. 2). The peculiarity of this genus consists in the endochrome being divided into four lamellæ, not parallel with the plane of the valves, but of the connecting zones.

C. A short filament of *Himantidium*, showing the curious fourfold curtain-like arrangement of the true endochrome, the nucleus as usual central.

D. *d*, front view of a frond of *Docidium*, a Desmid, intended to show that by cutting off the ends of the segments, *s s*, at the points indicated by the dotted lines, the front view would closely resemble the front view of the frustule of *Melosira* (a Diatom), of which the outline is given as E, the sectional outline or end view of the *Docidium* being represented as *e v*.

In the Diatom, as soon as division is completed, the true endochrome of each frustule splits up into two, and in some genera four, lamellar masses, each of which, from its remaining

unaltered in outline for a considerable period, would appear to have its own investing covering. But these masses, instead of occupying a position along the central region of the general chamber, are suspended, as it were, in the colourless protoplasm within, but not in immediate contact with the inner surface of the valve and connecting zone; the middle of the chamber, together with the space intervening between the lamellæ of endochrome, and the inner surface of the siliceous wall being occupied, just as in the Desmid, by colourless protoplasm.

On cursorily looking at a Diatom frustule—say of a *Navicula*—it might easily be supposed that the relative positions of the true endochrome and the siliceous wall, both before and after division, differ from those which obtain in the Desmid frond. Indeed, this mistake is a common one, due to the overlooked fact that, as a rule, division takes place in the Diatom in a plane which bisects the shortest axis of the organism; whereas, in the Desmid, it takes place in a plane bisecting the longest axis. In other words, the tranverse or short axis of the Diatom *frustule*, coincides with a line passing across the centres of *both* its valves; whereas the longitudinal axis of the Desmid *frond* corresponds with a line passing through the centre of both its *segments*. Or, to state the case in still another way, the front view of the Diatom *valve* (see fig. 5, A, *a*) corresponds with the end view of the frond or segment of the Desmid (D, *e e*); whereas the front view of the Diatom frustule (A, *b*, or C), and the front view of the Desmid frond (fig. 4, A, and fig. 5, D, *d*), represent corresponding aspects in the two kinds of organisms. This last-named correspondence of parts will be best understood, however, by comparing the figures of *Docidium* (a Desmid) fig. 5, D, *d*, with the front view of *Melosira*, a cylindrical but short Diatom, of which an outline representation is given at E.

Lastly, I have to touch briefly on the subject of the extra-frustular appendages as these present themselves in the Diatomaceæ. They may consist merely of a gelatinous mass, more or less shapeless, in which a colony of frustules is imbedded, as in *Dickieia*; of a tubular sheath of almost horny consistence, though perfectly hyaline, in which the separate frustules move freely, as in *Encyonema*; of stalk-like processes or pedicels which anchor the frustules to the substance from which they spring, as in *Cocconema*, or which constitute a kind of stem to a broad, fan-like expansion of frustules, as in *Licmophora*; of mere pads which connect the frustules of certain filamentous forms to each other, as in *Biddulphia*; of a highly elastic and yet subtle film which completely invests some of the filamentous bacillarian forms, and at the same time either permits of their peculiar movements, or itself contributes to the performance of these movements, as in that most remarkable of all Diatoms,

Bacillaria paradoxa; and lastly, of a flattened, quoit-shaped, hyaline expansion, surrounding the periphery of each valve, as in the beautiful oceanic Diatom, *Coscinodiscus sol*. Many more forms of these appendages might be enumerated differing as widely from each other as the above, not only in shape but in the purposes they apparently serve in the economy of the several species which possess them. I presume, however, that enough has been advanced to substantiate what I contend for—namely, that it is illogical to regard all these widely varying phases of this extra-frustular secretion as unconnected with some more specialized function in the protoplasm of the Diatom than has hitherto been ascribed to it. The different forms assumed cannot be fortuitous. Their permanence in certain species, and in these only, at once negatives any such idea. For the same reason it is hardly possible that they can be epiphytic or parasitic growths, which have nothing to do with the structure with which they are associated. Their perishable nature the moment the parent structure dies would almost seem to prove that they cannot be looked upon as absolutely effete matter whilst constituting an integral part of the living organism. The siliceous wall of the Diatom may be dead matter, just as dentine is, though still forming part of the living animal. But both these portions of structure are almost imperishable under ordinary conditions. There is, therefore, no analogy between the cases.

Of the movements observable in certain Diatoms much might be said that bears in an important degree on the present subject. For the present I must, however, rest content with repeating the conviction expressed by me nearly twenty years ago, in the "Annals," and again very recently in the "Monthly Microscopical Journal," that so palpably are these movements due to some subtle form of motile filaments that I do not hesitate to say it is but a question of time and properly directed skill when the nature of the organ, whatever its exact form may be, shall be revealed by the microscope, just as the long-suspected flagellum of one of the *Bacteria* has already been.

It only remains for me to add that, taking all the forthcoming facts into consideration, many of the most material of which my limits have precluded me from even naming in the present article, there seems to be ample ground for concluding that the Desmid and the Diatom, although undoubtedly presenting "closed-cells" within their structure, are not themselves mere cells consisting only of the parts, or homologues of the parts, which enter into the composition of the typical vegetable cell as ordinarily defined; but are, in reality, composite structures of which the cellular portion constitutes a small, though no doubt a very important, integral part.

THE NORWEGIAN LEMMING AND ITS MIGRATIONS.

By W. DUPPA CROTCH, M.A., F.L.S.

[PLATE IV]

AMONG the many marvellous stories which are told of the Norwegian lemming (*Myodes lemmus*, Linn.) there is one which seems so directly to point to a lost page in the history of the world that it is worth a consideration which it appears hitherto to have escaped. I allude to the remarkable fact that every member of the vast swarms which periodically almost devastate Norway perishes voluntarily, or at least instinctively, in the ocean. But as among my readers some may not be familiar with the lemming, a brief description of the animal itself will not be out of place. It is a vole, like our short-tailed field mouse, very variable in size and colour, but the figures (fig. 1), which are about half the natural size, will be found to resemble the majority in the latter respect. The claws, especially on the fore foot, are strong and curved, the tail is very short, the ears scarcely visible, and the beadlike, black eyes seem always to notice objects above them rather than those in any other direction. During the summer these animals form their nests under stones, usually betraying their habitations by the very care which they take to keep them sweet and clean. In winter, however, they form long galleries through the turf and under the snow in search of their food, which is exclusively vegetable; and it is at this time that those ravages are caused which have led the Norwegians in former times to institute a special form of prayer against their invasions. There are several species of lemming, easily recognizable, and with well-marked geographical range; but it is to the Scandinavian species only that the following old description applies. "It lives on the shoots of the dwarf birch, reindeer lichens, and other mosses; it hisses and bites; in winter it runs under the snow; and about every tenth year, especially before an extremely severe winter, the whole army of animals, in the autumn and at night, migrates in a direct line." According to Olaus Magnus they fall from the clouds; and Pennant narrates that "they descend from the Kolen, marching in parallel lines three

feet apart; they traverse Nordland and Finmark, cross lakes and rivers, and gnaw through hay and cornstacks rather than go round. They infect the ground, and the cattle perish which taste of the grass they have touched; nothing stops them, neither fire, torrents, lakes nor morasses. The greatest rock gives them but a slight check; they go round it, and then resume their march directly without the least division. If they meet a peasant they persist in their course, and jump as high as his knees in defence of their progress. They are so fierce as to lay hold of a stick and suffer themselves to be swung about

FIG. 1.



GROUP OF LEMMINGS.

before they quit their hold. If struck they turn about and bite, and will make a noise like a dog. Foxes, lynxes, and ermines follow them in great numbers, and at length they perish, either through want of food or by destroying one another, or in some great water, or in the sea. They are the dread of the country, and in former times spiritual weapons were exerted against them; the priest exorcised them, and had a long form of prayer to arrest the evil. Happily it does not occur frequently—once or twice only in twenty years. It seems like a vast colony of emigrants from a nation overstocked, a

discharge of animals from the northern hive which once poured forth its myriads of human beings upon Southern Europe. They do not form any magazine for winter provision, by which improvidence, it seems, they are compelled to make their summer migration in certain years, urged by hunger. They are not poisonous, as vulgarly reported, for they are often eaten by the Laplanders, who compare their flesh to that of squirrels."

M. Guyon disposes of the theory that these migrations are influenced by *approaching* severe weather, since the one witnessed by himself took place in the spring; also the superabundance of food during the previous autumn precluded all idea of starvation. He therefore adopts a third view, that excessive multiplication in certain years necessitates emigration, and that this follows a descending course, like the mountain streams, till at length the ocean is reached. Mr. R. Collett, a Norwegian naturalist, writes that in November, 1868, a ship sailed for fifteen hours through a swarm of lemmings, which extended as far over the Trondhjems-fjord as the eye could reach.

I will now relate my own experience of the lemming during three migrations in Norway, and in a state of captivity in England. The situation of Heimdalen, where I reside during the summer months, is peculiarly well suited for observation of their migrations, lying as it does at an elevation of 3,000 feet, and immediately under the highest mountains in Scandinavia, and yet, excepting during migration, I have never seen or been able to procure a specimen. It was in the autumn of 1867 that I first heard the peculiar cry of the lemming, guided by which I soon found the pretty animal backed up by a stone, against which it incessantly jerked its body in passionate leaps of rage, all the while uttering a shrill note of defiance. The black, beadlike eyes seemed starting from their sockets, and the teeth shone white in the sunlight. I hastily snatched at the savage little creature, but it sprang completely round, fastened its teeth sharply in my hand, and taking advantage of my surprise escaped under a large stone, whence I could not dislodge it. A Norwegian friend who accompanied me by no means shared my feelings of satisfaction at the sight of a lemming. "We shall have a severe winter and no grass next spring owing to those children of Satan!" was his comment on the event. However, it was many a month before I saw another, then, on lifting a flat stone I found six in a nest of dried grass, blind, and apparently but just born. In a few days the whole fjeld became swarming with these pretty voles; at the same time white and blue foxes made their appearance, and snowy owls and many species of hawks became abundant. My dogs, too, were annoyed by the rash courage of the new comers,

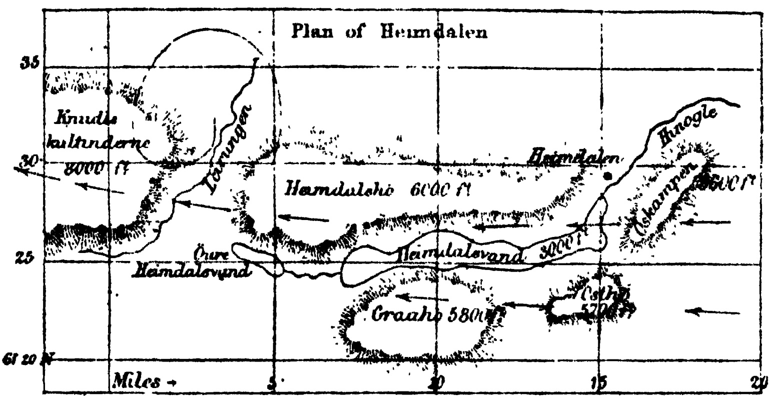
which would jump at their noses even when slowly drawing on game, so that they never spared a lemming, though they never ate them till last year, when I observed that they would eat their heads only, rejecting the body, although they devoured the common field mouse to the end of his tail. As the season advanced and snow covered the ground, the footprints and headless carcasses told plainly how hard it must be for a lemming to preserve its life, although there can be no doubt that its inherent pugnacity is its worst enemy. In this country we fail to conceive how much active life goes on beneath the snow, which in more northern latitudes forms a warm roof to numerous birds, quadrupeds, and insects, which are thus enabled to secure an otherwise impossible sustenance. At the same time, as I have already noticed, a fearful struggle for existence is carried on during the long autumnal nights before the snow has become a protection rather than a new source of danger to all save predaceous animals. It was a curious sight, when the whole visible landscape was of an unbroken whiteness, to see a dark form suddenly spring from the surface and scurry over the snow, and again vanish. I found that some of the holes by means of which this feat was executed were at least five feet in depth, yet even here was no safety, for the reindeer often kill the lemmings by stamping on them, though I do not believe their bodies are ever eaten.

During the autumn I noticed no migration, or rather there was only an immigration from some point to the eastward, and in the subsequent migrations of 1870-1 and 1875-6 I still found the same state of things. The animals arrived during early autumn, and immediately began to breed; there was no procession, no serried bands undeterred by obstacles, but there was an invasion of temporary settlers, which were speedily shut out from human view by the snow, and it was not till the following summer that the army, reinforced by five or six generations, went out to perish like the hosts of Pharaoh. On calm mornings my lake, which is a mile in width, was often thickly studded with swimming lemmings, every head pointing westward, but I observed that when my boat came near enough to frighten them they would lose all idea of direction and frequently swim back to the bank they had left. When the least wind ruffled the water every swimmer was drowned, and never did frailer barks tempt a more treacherous sea, as the wind swept daily down the valley, and wrecked all who were then afloat. It was impossible not to feel pity for these self-haunted fugitives. A mere cloud passing over the sun affrighted them; the approach of horse, cow, dog, or man alike roused their impotent anger, and their little bodies were convulsively pressed against the never-failing stone of vantage (see fig. 1), whilst

they uttered cries of rage. I collected 500 skins, with the idea of making a rug, but was surprised to find that a portion of the rump was nearly always denuded of hair, and it was long before I discovered that this was caused by the habit of nervously backing up against a stone, of which I have just spoken. As this action is excited by every appearance of an enemy it seems surprising that a natural callosity should not take the place of so constant a lesion; possibly, however, the time during which this lesion occurs is too short to cause constitutional change.

Early in the autumn, and just a year after their arrival at Heimdalen, the western migration commenced anew. Every

FIG. 2.



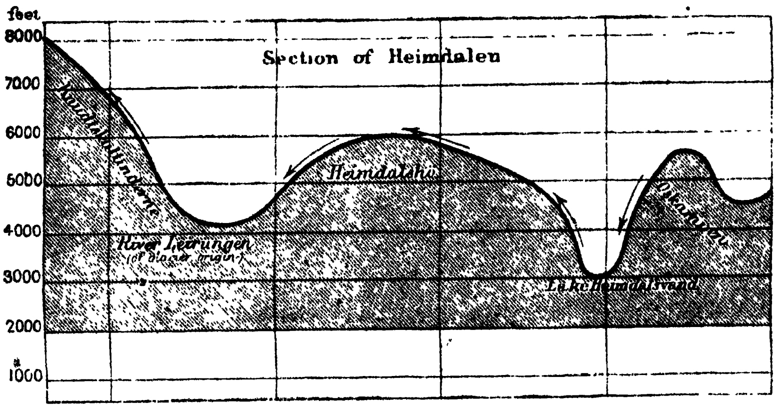
Plan of Heimdalen drawn to scale, in which the course of the Lemmings, indicated by the arrows, is seen to cross Lake Heimdalsvand and the swift river Leirungen, both of which might be avoided by a slight détour. The river is of glacier origin, very cold and very rapid.

morning I found swarms of lemmings swimming the lake diagonally instead of diverging from their course so as to go round it, and mounting the steep slopes of Heimdals-hö (figs. 2 and 3) on their way to the coast, where the harassed crowd, thinned by the unceasing attacks of the wolf, the fox, and the dog, and even the reindeer, pursued by eagle, hawk and owl (See Pl. IV.), and never spared by man himself, yet still a vast multitude, plunges into the Atlantic Ocean on the first calm day, and perishes with its front still pointing westward. No faint heart lingers on the way; and no survivor returns to the mountains.

There appears to have been a difficulty in keeping these restless creatures in captivity, both because they escape through in-

credibly small apertures (generally, however, dying from internal injuries thus caused), and because they will gnaw through a stout wooden cage in one night, and devote every spare moment to this one purpose, with a pertinacity worthy of Baron Trenck. At all events, few have been brought alive to this country, and none have survived. At present (February, 1877) I have one which I have preserved since September last, defeating his attempts at escape by lining the cage with tin, and allowing him a plentiful supply of fresh water, in which he is always dabbling. With the approach of winter all his attempts to escape ceased, and I now always take the little stranger for an airing in my closed hands whilst his bed is being made and his room cleaned out. He seems to like this, but after a few minutes a gentle nibble at my finger testifies to his impatience, and if this be not attended to the

FIG. 3.



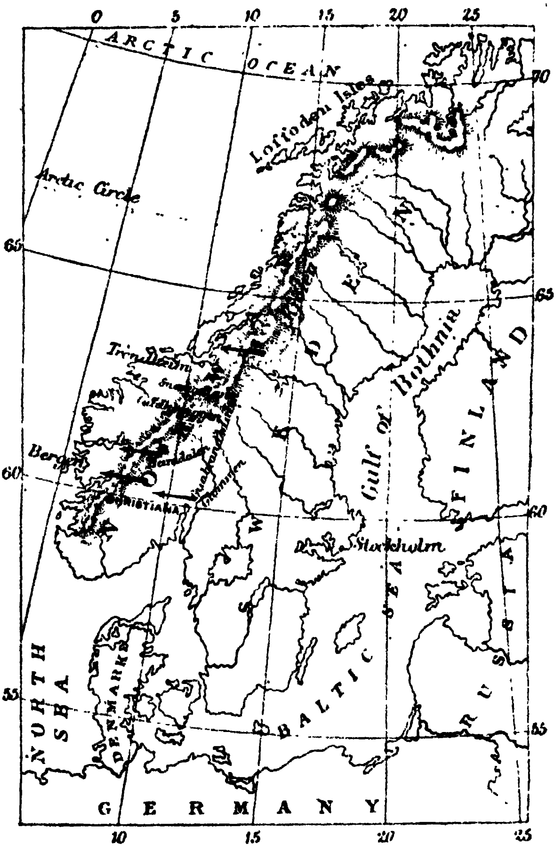
Section of Heimdalen showing the Lemmings' track, which does not follow the watershed.

biting progresses in a crescendo scale until it becomes unbearable, although it has never under these circumstances drawn blood. My little prisoner shows few other signs of tameness, but the fits of jumping, biting, and snarling rage have almost ceased. I expect, however, that with the return of spring the migratory impulse will be renewed, and that he will kill himself against the wires of his cage like a swallow.

The reader is now in a position to consider the three questions raised by the above facts, and those questions are as follow:— 1. Whence do the lemmings come? 2. Whither do they go? 3. Why do they migrate at all? With regard to the first, no one has yet supplied an answer. They certainly do not exist in my neighbourhood during the intervals of migration; and the Kjolen range was probably selected as their habitat, not because

it was proved to be so, but because so little is known about it at all. The answer to the second question is certain: they go to the sea. Those on the east of the backbone of Norway go to the Gulf of Bothnia, and those on the west to the Atlantic Ocean (fig. 4), and out of 18 migrations which have been investigated, one only, and that very doubtful, is reported

FIG. 4.



Outline map of Scandinavia. The two main valleys, Gudbrandsdalen, and the valley of the Glommen, run nearly north and south. The course of the Lemmings crosses there at right angles, as indicated by the arrows.

to have been directed southward. The question as to the cause of these migrations remains, and is a very difficult one to answer. We have been told that the foreknowledge of approaching severe weather predetermines the exodus: my experience, however, contradicts this, and it may be dismissed as merely a popular superstition. Unusual reproduction and

consequent deficiency of food is a more plausible theory, but I have always noticed that, just as with the swallow, a few individuals have preceded the main body, and that during the first autumn the numbers are never large, but after a winter spent beneath the snow they begin to breed with the first days of summer, and thus develop the extraordinary multitude which is, as it well may be, the astonishment and terror of the country. It appears, then, that excessive reproduction is rather the result than the cause of migration. It has also been suggested that the course taken by the lemmings follows the natural declivities of the country, but a reference to the maps will show that in that case nearly all the Norwegian migrations should take a southerly route, which is by no means the case. On the contrary, westward at Heimdal means across a rapid river, over a wide lake, and up a steep, rocky and snowy mountain, and this is the course which is followed. Now, this ends eventually in the ocean, and thus we are again landed at the question from which we set out. After all, it is not the power of direction which is so remarkable: this is a faculty possessed by many animals, and by man himself in a savage state. A young dog which I took from England, and then from my home in Vaage by a path to Heimdalen, a distance of 46 miles, ran back the next morning by a direct route of his own, crossing three rapid rivers and much snow, and accomplishing the distance in six hours, without the vestige of a path. This same dog afterwards repeated the feat, but followed the path, and took two days in reaching his destination, hindered and not aided, as I believe, by his experience. Herr Palmén, indeed, says "experience guides migration, and the older migrants guide the younger," like one of Mr. Cook's personally conducted tours. This obviously cannot be the case with the lemmings.

It is now generally admitted that instinct is merely inherited experience, and is therefore primarily calculated to benefit the species, unless indeed circumstances have changed meanwhile more rapidly than the structures to which the phenomena of instinct are due. Now, the lemmings during their wanderings pass through a land of milk and honey, where, if their instincts could be appeased, they might well take up a permanent abode, and yet they pass on, whilst their congener, the field-vole, remains in quiet possession of the quarters from which he was temporarily ousted. It is indeed almost as strange a sight to see the holes, the deeply-grooved runs, and the heaps of refuse of these restless creatures, which have passed away but yesterday, as it is to see the fjelds suddenly become alive with a new and boisterous tenant, who, like another Ishmael, has the hand of all men against him.

Now, if we compare the migration of the lemmings with that

of our more familiar swallows, we find that the latter obviously seek a more genial climate and more abundant food, returning to us as surely as summer itself; nor do they ever, so far as I know, breed on their passage. The swifts, which stay but a short time with us, remain in Norway barely long enough to rear their young before returning to Africa. It is difficult, in fact, to find a parallel case to that of the lemmings: the nearest approach, perhaps, is afforded by the strange immigration of Pallas's sand-grouse in 1863, when a species whose home is on the Tartar Steppes journeyed on in considerable numbers to the most western shores of Europe, and very probably many perished, like the lemmings, in the waves of the Atlantic. But to revert to the swallows, which annually desert Europe to visit Africa. Let us suppose that these birds were partial migrants only—that is, that a remnant remained with us after the departure of the main body—and further suppose that the continent of Africa were to become submerged, would not many generations of swallows still follow their inherited migratory instincts, and seek the land of their ancestors through the new waste of waters, whilst the remaining stock, unimpeded by competition, would sooner or later, according to the seasons, recruit the ranks for a new exodus? It appears quite as probable that the impetus of migration towards this lost continent should be retained as that a dog should turn round before lying down on a rug, merely because his ancestors found it necessary thus to hollow out a couch in the long grass.

Well, then, is it probable that land could have existed where now the broad Atlantic rolls? All tradition says so: old Egyptian records speak of Atlantis, as Strabo and others have told us. The Sahara itself is the sand of an ancient sea, and the shells which are found upon its surface prove that no longer ago than the Miocene period a sea rolled over what now is desert. The voyage of the "Challenger" has proved the existence of three long ridges in the Atlantic Ocean, one extending for more than three thousand miles; and lateral spurs may, by connecting these ridges, account for the marvellous similarity in the fauna of all the Atlantic Islands. However, I do not suppose that the lemmings ever went so far south, though they are found as fossils in England; but it is a remarkable fact that whilst the soundings off Norway are comparatively shallow for many miles, we find a narrow but deep channel near Iceland, which probably has prevented the lemming from becoming indigenous there, although an American species was found in Greenland during the late Arctic Expedition. If, as is probable, the Gulf Stream formerly followed this deep channel, its beneficent influence would only extend a few miles from the coast, which would also have reached to a great

distance beyond the present shores of Norway, and thus the lemmings would have acquired the habit of travelling westward in search of better climate and more abundant food; and as little by little the ocean encroached on the land the same advantages would still be attained. And thus, too, we find an explanation of the fate which befalls the adventurous wanderers; for we have already seen that no lake deters them, and that they frequently cross the fjords, or arms of the sea, in safety. No doubt, therefore, they commit themselves to the Atlantic in the belief that it is as passable as those lakes and fjords which they have already successfully dared, and that beyond its waves lies a land which they are never destined to reach.

The submerged continent of Lemuria, in what is now the Indian Ocean, is considered to afford an explanation of many difficulties in the distribution of organic life, and I think the existence of a Miocene Atlantis will be found to have a strong elucidative bearing on subjects of greater interest than the migration of the lemming. At all events, if it can be shown that land existed in former ages where the North Atlantic now rolls, not only is a motive found for these apparently suicidal migrations, but also a strong collateral proof that what we call instincts are but the blind and sometimes even prejudicial inheritance of previously acquired experience.

THE ALKALINE AND BORACIC LAKES OF CALIFORNIA.

By J. ARTHUR PHILLIPS, F.G.S.

IMMEDIATELY east of the range of the Sierra Nevada is an extensive region of alkaline lakes and hot springs, of which very large areas are almost totally barren, the only vegetation consisting of wild sage, yucca, a few cacti, and scanty tufts of bunch-grass.

This district affords, in its many extensive craters and in its lavas, basalts and obsidians, the most conclusive evidence of its volcanic origin, while its solfataras and boiling springs may be regarded as the last representatives of active vulcanicity.

Although this region is one of great scientific interest, and may eventually become industrially important, it appears to be but little known in this country, and it has therefore been thought that a brief description of the district, as well as of that of the borax lakes, lying on the western side of the Sierra, might not be without interest to English readers.

The most remarkable of the alkaline lakes of this portion of California are Mono and Owen's Lakes. The former lies in a depression occupying a portion of an elevated plateau of desert land, situated at the eastern base of the Sierra Nevada between the head waters of Owen's and Walker's Rivers. The distance from the summit of the range to the lake-shore is about six miles, and the difference of elevation is about 6,000 feet. On all sides, excepting towards the Sierra, this lake is surrounded by a wide belt of desert, the total area of which is from 400 to 500 square miles.

Mono Lake is about fourteen miles long, from east to west, and nine wide, from north to south; but it was formerly much larger than it is at present; this is indicated by numerous terraces, by means of which the lines of its ancient shores may be readily traced.

The water of this lake, which has a high specific gravity, and is alkaline and extensively saline, is not easily thrown into

waves, but is generally smooth and glassy. Near its north shore there are springs which have produced extensive deposits of tufa, some of which rise several feet above the surface in forms resembling gigantic fungi.

There are numerous islands in this lake, two of which are of considerable size, the largest being two and a-half miles long, from north to south, and the other about half a mile in length, from east to west. These, as well as a group of smaller islets lying to the north, are entirely composed of volcanic materials.

On the north-eastern corner of the larger island are extensive hot springs and steam-jets, covering an area of some thirty acres, and extending into the lake. The escape of steam and hot gases from so many hundreds of vents is attended with much noise, and the sides of the orifices of many of the fumaroles are incrusted with a reddish-brown substance, which is probably chloride of iron. In the neighbourhood of these springs there is a slight smell of sulphurous acid, but no free sulphur is deposited. Some of them furnish a copious supply of boiling water, large quantities of which enter the lake, and so perceptibly raise its temperature for a considerable distance around. Much gas and steam escape from a fissure caused by the sinking of a portion of the crust, while on the eastern part of the island are two well-defined craters, now filled with water.

Mono Lake is, during the summer, the resort of myriads of gulls and other aquatic birds, which are most numerous during the breeding season, but the water is believed to be entirely destitute of life, with the exception of a small crustacean, *Artemia fertilis*, nearly related to the so-called brine shrimp (*Artemia salina*) found in the strong brine of the salt pans on European coasts, and the *Koo-chah-bee* of the Indians, a whitish larva, occurring in immense quantities, and which is much esteemed by them as an article of food.

Stretching south of the lake is a chain of extinct volcanoes, presenting the form of truncated cones, of which the generally steep sides are covered with ashes and other loose materials. Obsidian and pumice are abundant on the surface of these cones, and also cover the plains at their base.

Owen's Valley is a narrow basin lying south of Mono Lake, and running nearly north and south for a distance of about 140 miles. Its average width may be taken at ten miles. It is bounded along its western edge by the Sierra Nevada, which in this portion of its course presents an almost unbroken wall, of which the highest peak, opposite Owen's Lake, reaches an elevation of 15,000 feet. No pass crosses it at a less height than 11,000 feet, and near the lake-shore the descent from the summit to the valley beneath must have an average inclination of at least 1,000 feet per mile, the distance being from ten to eleven

miles, and the difference of level between the highest point of the pass and the valley being from 10,500 to 11,000 feet.

On the eastern side of this valley are the Inyo Mountains, towards its southern end, and the White Mountains further north. This range is dry and desert-like, and not a single stream of any size flows from it into Owen's Valley, which is exclusively watered by the melting of the snows accumulated during the winter months on the eastern slope of the Sierra. Owen's River rises a short distance from the source of the San Joaquin, and, after flowing for a distance of 120 miles, falls into Owen's Lake in lat. 36° 20′ N., long. 118° W. from Greenwich. This lake, of which the water is exceedingly saline and strongly alkaline, is twenty miles long and eight wide. It has no visible outlet, and its shores are often thickly coated with a snow-like alkaline incrustation.

No fish inhabits its waters, but *Koo-cha-bee* is abundant, and at certain seasons is carried in by the waves and deposited on the shores in layers of several inches in thickness. This was formerly collected in large quantities by the Indians, and, after being dried in the sun, rubbed between the hands and roughly winnowed, was crushed in a stone mortar, and made into a sort of bread, which furnished an important article of food. This insect, which has been described as a white grub, is also found abundantly in the waters of Great Salt Lake, Utah, and those of other saline and alkaline lakes of the west, and appears to be the larva of a two-winged fly which is described by the late Professor Torrey under the name of *Ephydra californica*, and by Dr. A. S. Packard as *Ephydra gracilis*.*

A specimen of water taken from Owen's Lake, in January, 1866, had a specific gravity of 1·076, and contained 7128·24 grains of solid matter per gallon. The composition of this residue was found, calculated on an imperial gallon, to be as follows:—

Chloride of sodium	2942·05
Sulphate of sodium	956·80
Carbonate of sodium	2914·43
Sulphate of potassium	122·94
Phosphate of potassium	35·74
Silicate of potassium	139·34
Organic matter	16·94
	7128·24

In addition to the substances above enumerated, iodine was present, but only in such minute proportion that its amount

* See Hayden, "Geological Survey of Montana, Idaho, Wyoming, and Utah, 1872," p. 744.

could not be estimated. It is also to be observed that since, for convenience of carriage, the sample of this water operated on was reduced by evaporation to one-fourth of its original bulk before being brought to this country for analysis, it is probable that some alkaline sesquicarbonates may have been originally present.

The incrustations which at certain periods of the year accumulate to the extent of many hundreds of tons on the shores of this lake, mainly consist of carbonates of sodium, in which the proportion of sesquicarbonate is somewhat variable; in some specimens examined monocarbonates were alone present. Besides carbonates of sodium, these deposits contain 3 per cent. of chloride of sodium, and about 5 per cent. of sulphate of sodium, together with traces of silica.

It was proposed some years since to erect works on the eastern shore of Owen's Lake, for the purpose of refining this deposit, for the manufacture of merchantable carbonate of sodium; but whether this idea was ever carried out, I am not aware. The only serious obstacles to the success of such an enterprise would appear to arise from scarcity of fuel, and the great distance of the lake from a shipping port.

As this lake continuously receives the waters of a considerable and constantly flowing river, while it has no apparent outlet, it follows that it must act the part of a huge evaporating basin, in which the salts introduced by the not apparently saline water of Owen's River become concentrated to an alkaline brine. The rocks on either side of the valley through which the river flows are, to a very large extent, composed of granites, lavas, and basalts, from the decomposition of the felspars in which the alkaline salts of the lake have doubtless been derived. The very small proportion of potassium salts present in these waters is remarkable, for although from the circumstance of the felspars of the district being to a large extent triclinic, sodium might be expected largely to predominate, still so great a disproportion in the respective amounts of the two alkalies could scarcely have been anticipated. This circumstance may perhaps, to some extent, be accounted for by supposing the potassium salts to have been largely assimilated by plants during the percolation of the waters containing them through vegetable soil, while the salts of sodium, not having been thus arrested, have passed into the river, and thence into the lake.

Owen's, like Mono Lake, was at one time much more extensive than it is at present; this is evident from the occurrence of a series of parallel terraces, plainly traceable on each side of the valley. In addition to these lakes, numerous alkaline lagunes and boiling springs are met with throughout this region.

The *Artemia fertilis*, before referred to as being plentiful in Mono Lake, is also exceedingly abundant in Owen's Lake. A peculiarity of this crustacean is that it congregates into masses which have often a strange appearance in the water. These masses sometimes stretch out in such a way as to have the form of a serpent, while at others they represent circles or various irregular figures. A gentle breeze scarcely affects water filled by *Artemiæ*, so that while on all sides the water is slightly ruffled, that which is occupied by these dense aggregations remains perfectly smooth, thus indicating the figure of the mass. On placing some of these crustaceans in a bottle filled with lake water, for the purpose of preserving them for subsequent microscopical examination, it was found that those which died rapidly disappeared, and on closely examining what had taken place, it soon became evident that as soon as vitality had ceased, chemical action was set up, and the animal gradually dissolved in the strongly alkaline brine.

Burton Springs are situated at the extreme northern point of Owen's Valley. These springs rise from the earth over an area of about eighty square feet, which forms a basin or pond that pours its heated waters into a narrow creek. In this basin a vegetable growth is developed at a temperature of about 160° F., and is continued into the creek to a distance of about a hundred yards from the springs; where, at a temperature of about 120° F., the algæ grow to a length of over two feet, looking like bunches of waving hair of a beautiful green colour. Below the temperature of 100° F., these plants cease to grow, and give way to a slimy fungus, which is also green in colour, but finally disappears, as the temperature of the water decreases. Dr. J. H. Wood, junr., who has carefully examined this growth, makes the following observations with regard to it:—"This plant certainly belongs to the *Nostochaceæ*, and seems a sort of connecting link between the genera *Hormosiphon* of Kützing and *Nostoc*.

"The best algologists now refuse to recognize the former group as generically distinct, and the characters presented by this plant seem to corroborate this view.

"The species appears to be an undescribed one, and I would propose for it the specific name *Caladarium*, which is suggested by its place of growth." *

Twenty miles south from Owen's Lake, across a sage-brush and grease-wood waste, the surface of which is plentifully strewn with fragments of lava, pumice and basalt, is Little Lake. This sheet of water, which is of comparatively small extent, is surrounded by huge masses of contorted vesicular lava, and

* "Silliman's Journal," vol. xlvi. 1868, p. 33.

evidently occupies the cavity of an ancient volcanic vent. The waters of this lake are considerably less alkaline than those of Owen's Lake, but bubbles of carbonic acid make their way to its surface in almost uninterrupted streams.

Fifteen miles east from this point are numerous hot springs; the path for the greater portion of this distance lies over lava-flows, which render travelling slow and fatiguing. At the principal group of springs the ground is covered, over a large extent, by innumerable cones of plastic mud, varying in height from a few inches to several feet; these rise above the surface of a seething swamp, and give issue to steam and jets of boiling water. In some cases the steam and gases, instead of issuing from cones as above described, are evolved under the surface of water and mud contained in basin-shaped reservoirs formed in the decomposed rock. By these means are produced multitudes of boiling cauldrons in which violent ebullition keeps clay in a constant state of suspension; this clay varies in colour from bluish grey to bright red. The waters of these springs are much employed by the Indians as an embrocation for the cure of diseases of the eye; on examination they were found to contain 48 grains of solid matter to the gallon, of which amount 26 grains are sulphate of aluminium; in addition they contain lime, soda, potash, and a little free sulphuric acid.

Borates of sodium and calcium occur in various localities in North America. The two borax lakes are both situated near the shores of Clear Lake in Lake County, California, seventy miles north-west of the port of Suscol, and one hundred and ten from the city of San Francisco.

The larger of these lakes is separated from Clear Lake by a low ridge of volcanic materials loosely packed together, and consisting of scoriæ, obsidian, and pumice; it has an average area of about three hundred acres. Its extent however varies considerably at different periods of the year, as its waters cover a larger area in spring than during the autumnal months. No stream flows into its basin, which derives its supply of water partly from drainage from the surrounding hills, and partly from subterranean springs discharging themselves into the bottom of the lake. In ordinary seasons its depth thus varies from five feet in the month of April to two feet at the end of October.

The borax occurs in the form of crystals of various dimensions imbedded in the mud of the bottom, which is found to be most productive to a depth of about three and a-half feet, although a bore-hole which was sunk near its centre to the depth of sixty feet afforded a certain amount of the salt throughout its whole extent.

The crystals thus occurring are most abundant near the centre

of the lake, and extend over an area equivalent to one-third of its surface; they are, however, also met with in smaller quantities in the muddy deposit of other portions of the basin. The largest crystals, some of which are considerably above a pound in weight, are generally enclosed in a stiff blue clay, at a depth of between three and four feet; and a short distance above them is a nearly pure stratum, from two to three inches in thickness, of smaller ones; in addition to which crystals of various sizes are disseminated through the blue clayey deposit of which the bottom consists.

Besides the borax thus existing in a crystallized form, the mud itself is highly charged with that salt, and, according to an analysis by Dr. Oxland, affords, when dried, in those portions of the lake which have been worked (including the enclosed crystals), 17·73 per cent. Another analysis of an average sample, by Mr. G. E. Moore, of San Francisco, yielded 18·86 per cent. of crystallized borax. In addition to this the deposit at the bottom of the other portions of the basin, although less productive, still contains a large amount of borax.

Water collected from Borax Lake, in September, 1863, was found by Mr. Moore to contain 2401·56 grains of solid matter to the gallon, of which about one-half was common salt, one quarter carbonate of sodium, and the remainder chiefly anhydrous borax, equal to 535·08 grains of crystallized salt to the gallon. Traces of iodine and bromine were also detected. A sample of water taken from the interior of a coffer-dam sunk in the middle of the lake, and which had been allowed to fill by percolation from the bottom upwards, was found to be more concentrated, yielding 3573·46 grains of solid matter to the gallon, but it contained the same ingredients, and in nearly the same proportions, as the water from the lake itself. When evaporated to dryness, this water yields a considerable quantity of finely divided carbon, resulting from the various organic bodies which have been dissolved in it.

Mud from the bottom of Borax Lake is in high repute among the local Indians as an *insecticide*, and is used in the following way. The head of the patient is thickly plastered with mud, which is well rubbed in, and then allowed to become perfectly dry; when dry, it is removed by rubbing between the hands, and with it disappears the colony of parasites. Ordinary clay is, under pressure of circumstances, sometimes employed for this process of shampooing, but when alkaline or boracic mud is available, it is considered more efficacious.

When this locality was visited by me in 1866, borax was manufactured exclusively from the native crystals of crude salt, while the mud in which they were found was returned to the lake after a mechanical separation of the crystals by washing. The extrac-

tion of boracic mud was effected by the aid of sheet-iron coffer-dams. The only apparatus employed consisted of a raft, covered by a shingled roof, provided with an aperture in its centre about fifteen feet square, above which were hung, by suitable tackle, four coffer-dams, each six feet square in horizontal section, and nine feet in depth. This raft, or barge, was successively moored in parallel lines across the surface of the lake, and at each station the four dams were sunk simultaneously by their own weight into the mud forming the bottom.

When they had thus become well imbedded, the water was baled out, and the mud and crystals removed, by means of buckets, into rectangular washing-vats, into which a continuous stream of water was introduced from the lake by Chinese pumps, the contents being at the same time constantly agitated by the aid of wooden rakes. In this way the muddy water continually flowed off, finally leaving a certain amount of crude borax at the bottom of each tank; this was purified by re-crystallization. From the density acquired by the 70,000 gallons of water daily employed for this purpose, it is evident that only about one-half of the borax existing in the form of crystals was thus obtained, while the mud was again returned to the lake.

Instead of the coffer-dams, a small hand-dredging machine, worked, like the former, by Chinese labour, was subsequently introduced; but the mud brought up by it was subjected to the wasteful process of washing before described.

The crystals of crude borax thus daily obtained amounted to about 3,000 lbs.; these were dissolved in boiling water, and re-crystallized in large lead-lined vessels, from which the purified salt was removed to be packed into boxes, each containing 114 lbs., in which it was forwarded to San Francisco. The loss of weight experienced in the process of purification amounted to about 13 per cent.

Shortly after my visit in 1866, the manufacture of refined borax at "Big Borax Lake" was suspended, and I am not aware whether it has now been resumed, but the works do not appear to have been in operation in 1874.

Little Borax Lake covers an area of about thirty acres, and is usually dry during the months of September and October; it is then covered by a white crust, which is collected by Chinese labourers, and carried to the works, where it is refined by re-crystallization. *Ulexite*, a double borate of sodium and calcium, is brought to this place from Wadsworth, in the State of Nevada—a great distance, with several transhipments—to be treated at these works; it appears that on account of the presence of carbonate of sodium, and the cheapness of fuel, this can be done more cheaply here than in Nevada.

Clear Lake is a large and picturesque sheet of water, twenty-

five miles long, by about seven wide, surrounded by mountains, which in many places rise abruptly from the water's edge. Boat-life on this lake is delightful; the water is smooth, there is usually a sufficient breeze for sailing, and should it fall calm, an Indian can always be hired to row.

Lying about a mile beyond the ridge which borders Borax Lake on the north-east, and at the foot of a shorter arm of Clear Lake, which extends off to the southward parallel with the larger one, is an interesting locality, known as the "Sulphur Bank." It is some six or seven acres in extent, and consists of a much decomposed volcanic rock traversed by innumerable fissures, which has become almost covered by a large accumulation of sulphur.

From the fissures steam and gas are constantly issuing, and over and through the mass large quantities of sulphur have been deposited in such a way that at a short distance the whole bank appears to consist of this substance. Into some of these cavities a pole may be inserted for a distance of several feet, and they are often lined with stalactites and beautiful crystallizations of sulphur.

Sulphur is being constantly deposited, and its deposition is attended by the evolution of carbonic and boric acids. The gaseous matters issuing from these crevices appear to be the agency by which the various substances now deposited in the cavities have been brought to the surface. Sulphur is deposited on the sides of the various fissures either in the form of crystals, or as amorphous translucent masses of a beautiful yellow colour. It is sometimes intermixed with cinnabar, the presence of which was first discovered by Dr. Oxland; but more frequently with minute cubical crystals of iron pyrites. Pulverulent silica, blackened by some hydrocarbon resembling coal-tar, is also frequently observed.

On the sides of the cavities colloid silica is found coating chalcedony and opalescent quartz in the various stages of formation, from the gelatinous state to that of the hardest opal. The indurated material is sometimes colourless, but is more frequently permeated by cinnabar and iron pyrites, or blackened by the tarry matter before referred to. Cinnabar is also found in laminæ, and occasionally even in veins and concretionary masses of considerable thickness.

In addition to being employed as a source of sulphur, this deposit has been worked for quicksilver, and has produced large quantities of that valuable metal.

On the shore of Clear Lake, near the sulphur bank, is a hot spring, of which the outlets, even when the water is low, are partially beneath the lake, so that the amount flowing from it cannot be ascertained. Hot water, however, rises through the

sand at various points extending over a considerable area. A specimen of water collected by Mr. Moore from this spring was found by him to contain 184·62 grains of common salt, 76·96 grains of bicarbonate of sodium, 36·37 grains of free carbonic anhydride, 103·29 grains of borax, and 107·76 grains of bicarbonate of ammonium, in an imperial gallon; besides silica, alumina, and traces of various other substances.

Professor Whitney remarks with regard to this spring:—"The most extraordinary feature in the above analysis is the very large amount of ammoniacal salts shown to be present in this water, in this respect exceeding any natural spring-water which has ever been analysed. Mr. Moore thinks that, as in the case of the boracic acid waters of Tuscany, this ammoniacal salt may be separated and made available for economical purposes. This locality is worthy of a most careful examination, to ascertain how considerable a flow of water can be depended on." *

Dr. A. Blatchly, of San Francisco, in speaking of the Geyser group of quicksilver mines, says:—"Nearly all these veins contain iron in considerable amounts, frequently in sufficient quantities to constitute an ore of iron. Gold, silver, and copper are also frequently constituents of these lodes, and occasionally chrome iron in considerable quantities. But, so far as is known, in no instance have the precious metals been sufficiently abundant to pay for the expense of extraction.

"Bitumen is found in nearly all these veins, sometimes a deposit of a gallon or two in one cavity.

"Thermal springs are numerous throughout the whole quicksilver-region, and the uniformity of their occurrence leads prospecters to the belief that there is an intimate relation between the causes which generate thermal springs, and produce deposits of cinnabar, and that where one is found the other may probably occur in the vicinity." †

On the eastern slope of the Sierra Nevada, near Walker's Pass, borax is found in what appears to be the bed of an ancient lake, large crystals of this substance having been met with in a hardened mud, exactly resembling those found in the blue clay of Borax Lake. By far the largest amount of borax is, however, obtained from the indurated mud, where it exists in common with other salts. This mud, from which borax is separated by lixiviation, contains about half its weight of that salt, and is a light clay-like body, having a strongly saline and alkaline taste. The portion insoluble in water effervesces on

* "Geological Survey of California," p. 100.

† "Mineral Resources West of the Rocky Mountains," 1875, p. 176. Raymond.

being attacked by hydrochloric acid, and contains silica, alumina, lime, ferrous oxide, and magnesia. Similar deposits containing borax exist in Panamit and Death's Valley, in Lower Nevada; but these desolate districts have not as yet received so careful an examination as they deserve.

About twenty miles west of San Bernardino is the so-called "Cane Spring District," where ulexite or boronatrocalcite is found, over an area about ten miles in width by fifteen in length. The surface of the ground is covered by efflorescent salts, commonly known as "alkali," beneath which the borax salts (chiefly ulexite) are found at a depth of only a few inches.

At Hot Springs, in the north-western portion of the State of Nevada, at a height of 4,500 ft. above the level of the sea, and where the water issuing from the ground has a temperature of about 190° Fah., there are deposits of boronatrocalcite, extending over considerable areas. Here, as far as the eye can reach, nothing is seen but barren mountains, formed of a black porous lava; while the valleys are covered by an efflorescence of a mixture of common salt and sulphate and carbonate of sodium. In other cases the sands of these mountain valleys contain deposits of more or less pure boronatrocalcite.

Geysers and hot springs are numerous in the whole of this district, and from the number of extinct geyser vents still visible, they were, probably, at one time much more numerous than at present.

The analysis of an average sample of the boracic material from Nevada afforded Mr. Loew the following results:—

Boronatrocalcite	22·13
Chloride of sodium	2·80
Sulphate of sodium	2·62
Sulphate of calcium	6·17
Carbonate of calcium	3·01
Carbonate of magnesium	·79
Clay	19·70
Quartzose sand	26·03
Water	15·04
Traces of potash, iodine, and loss	1·71
	100·00 *

The purification of crude borax (*tincal*) is effected by a simple re-crystallization, but the preparation of marketable borax from boronatrocalcite is attended with considerable difficulty, more particularly as the appliances available in the remote deserts in which it occurs are of the most primitive and limited description.

* "Moniteur Scientifique," 1876, p. 1230.

When boronatrocalcite is moderately pure, it is first ground and subsequently dissolved in water, with the addition of an amount of carbonate of sodium sufficient to effect the decomposition of the calcic carbonate present.

The solution is subsequently heated, and the carbonate of calcium allowed to subside, when the liquor is drawn off, and, after concentration, borax is obtained by crystallization.

Unfortunately, this mineral often contains notable quantities of gypsum, which transforms an equivalent amount of carbonate of sodium into Glauber salt, a relatively valueless product. This salt is also frequently present in the material operated upon, and thus materially adds to the difficulty of treatment. In order to avoid these difficulties, it has been proposed to treat native boronatrocalcite with sufficient sulphuric acid to transform the whole of the carbonate of calcium into gypsum, and to liberate boric acid, to be subsequently saturated by carbonate of sodium. Boronatrocalcite has also been treated with excess of hydrochloric acid, in order to obtain crystallized boric acid, but neither of these processes has hitherto afforded satisfactory commercial results.

The comparatively recent discovery of large quantities of this substance in Nevada will, no doubt, eventually to some extent, affect the Tuscan producers of boric acid; but the fact that crude boronatrocalcite varies considerably in its composition, and that it is found in situations in which its local treatment would be almost impossible, has hitherto prevented this mineral from being extensively employed as a source of commercial borax.

CAN WEATHER BE PREDICTED IN THE BRITISH ISLES?

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SOME of our readers may have heard of Arago's famous saying, in the "Annuaire of the Bureau des Longitudes" for 1846, "Jamais, quels que puissent être les progrès des sciences, les savants de bonne foi et soucieux de leur réputation ne se hasarderont à prédire le temps," and yet, within fifteen years after that dictum was published, a regular service of storm warnings had been organized in England, France, and Holland; and now, at the expiration of thirty years, we could name more than one "savant de bonne foi et soucieux de son réputation" who considers the prediction of weather to be a subject of investigation which promises reasonably satisfactory results.

When we speak of the prediction of weather, however, we refer more particularly to the prediction of storms or of transient disturbances of the atmosphere; for if we come to consider the problem of really foretelling weather for the practical purposes of the farmer—of informing him, months beforehand, what crops he may put into the ground with a reasonable prospect of a paying return, or even days beforehand, when he may cut his hay or reap his corn with a fair probability of saving it without rain, we must admit that we have not made one step in advance of the position laid down for us by Arago thirty years ago. What is our most recent experience? A rainfall in the month of December of 5·82 inches in London, being three times the average fall in the month for the last sixty years, and exceeding by 16 per cent. the very heaviest fall in December during that period. To go a little further back, the year 1872, in its widespread and persistent rainfall, was almost unparalleled since accurate measurements have been kept; the total excess over the United Kingdom amounting to 36 per cent. of the annual fall, and surely we might have expected that some years' respite from the plague of waters was due to us,—but what have been the real facts? Only three years later, in the autumn of 1875, the damage caused by successive floods exceeded anything that modern records showed; and a short fifteen months later, in the

past winter, the whole of the low-lying lands of England have been submerged. Now, in March, the railway trains have just ceased carrying boats on some lines; and in Scotland we hear of thousands of acres of the richest land lying fallow for the year owing to the utter impossibility of working the soil in its present water-logged condition.

Articles in the papers may repeat *ad nauseam* that engineers are to blame for this state of things, and there can be no doubt that much more might have been done to regulate the water supply of the country than has yet been effected; but, on the other hand, engineers may fairly retort "Forewarned would be forearmed," and ask why meteorologists did not give them some hint of the deluges which were impending.

Meldrum and others have of late devoted much attention to the investigation of a supposed periodicity of rain according with that of sunspot frequency, with some measure of success, but no one yet has, in his wildest dreams, imagined that he could forecast the amount of rainfall for a given district in England at the epoch of the next sunspot maximum.

Talking about floods, however, there is one matter which deserves most serious consideration, and is far from encouraging for our future prospects. This is that, as a result of civilization, floods are increasing in their intensity, the rainfall being supposed to be unchanged in amount. This appears most unmistakably from the reasoning of M. Wex, the well-known hydraulic engineer of Vienna, and he is supported by other authorities. Rivers such as the Danube or Volga are gradually, but surely, becoming less and less navigable in the upper part of their course, while the floods in the lower part are becoming more and more disastrous. The reason of this is that the reckless clearing of forest land has altered the whole condition of the water flow of the country. The land, bared of its forest, can no longer retain the rain water which falls on it, and yield it slowly for the supply of springs. The rain pours in torrents down the hill sides, sweeping before it soil, gravel, and boulders, which it deposits in the calmer waters of the river bed, creating shoals unknown in more fortunate times; while, at the same time, this rapid discharge of the water from the surface causes a delivery within a few days which would have taken weeks or months to complete itself under more primitive conditions. The water which should have lain in the ground as provision against the summer drought is discharged at once, to the immediate detriment of the lower country inundated by the rapid rise of the river, and to the prospective loss of the upper country, owing to the deficiency of water for navigation, or for the purposes of agricultural irrigation.

In this country our forests disappeared long enough ago, but

overdraining exerts a similarly pernicious effect to the clearing of woodland. The upper proprietors demand that the land shall be drained as perfectly as possible. Thereby the water which should have lain in the soil for months escapes at once, and causes the river level to rise at the lower part of its course, washing the unlucky residents on its banks out of house and home.

This is, however, a digression, and as to the prediction of weather we may say that it has not at the present time been shown to be feasible to forecast weather for one short week, except on the principle, which affords us scanty consolation, that weather, when once well established, takes a long time to change. This comes out very clearly from the researches of M. Köppen, at present engaged at the Deutsche Seewarte at Hamburg. He has shown in a paper in vol. ii. of the "Russian Repertorium für Meteorologie" that if we investigate weather changes by the laws of probability we find that, as regards temperature, if a cold five-day period sets in after warm weather we may bet two to one that the next period will be cold too; but if the cold has lasted for two months, we may bet nearly eight to one that the first five days of the ensuing month will be cold likewise. This does not mean that the chances are in favour of the weather never changing, but are only against its changing on a definite day, and increase with the length of time the existing weather has lasted. The problem is somewhat similar to that of human life: the chance of a baby a year old living another year is less than that of a man of thirty living to be thirty-one.

There is one very interesting idea which, if it could be worked out, would be of great value to us, and that is that we could foresee the coming of such a winter as we have just passed through if we had regular and early information as to the state of sea temperature off the coast of Portugal during the late autumn. Franklin, in 1776, traced the Gulf Stream right across the Atlantic in November, and found a temperature as much as 5°·5 above the mean for the month at one spot in about 10° W. and 45° N. Now in January 1822, H.M.S. *Iphigenia*, nearly on the same spot, found a temperature 3°·2 above the average in 44° 30′ N.; the difference increased to 6° in 39° N., and again diminished to 4° in 32° 20′ N., while at the same period the general temperature in the adjoining parallels, both to the northward and the southward, even as far as the Cape Verde Islands in 19° 40′, was colder by a degree and upwards than the usual average. We quote from Sabine's "Pendulum and other Experiments," p. 430. The same writer goes on to say: "Nor is the probable meteorological influence undeserving of attention of so considerable an increase in the temperature of the surface

water over an extent of ocean exceeding 600 miles in latitude and 1,000 in longitude, situated so importantly in relation to the western parts of Europe. It is at least a remarkable coincidence that in November and December 1821, and in January 1822, the state of the weather was so unusual in the southern parts of Great Britain and in France as to have excited general observation. In the meteorological journals of the period it is characterised as 'most extraordinarily hot, damp, stormy, and oppressive;' it is stated that 'an unusual quantity of rain fell both in November and December, but particularly in the latter;' that 'the gales from the W. and SW. were almost without intermission,' and that in December the mercury in the barometer was lower than it had been known for thirty-five years before."

Now if we compare these statements with our experience of the winter we have just come through we shall find that the principal features in 1821-2 to which Sir E. Sabine refers were manifested in an exaggerated degree in 1876-7. We are told by Prof. Daniell that the mean pressure of December 1821 was considerably below the mean. 29·467 in. is given as the value, but it does not appear whether these figures are reduced to sea level or not. Now the mean pressure of last December was 29·486, being nearly half an inch lower than its average figure for the month, 29·943 ins., as given by Buchan for eighty-nine years' observations. The extraordinary low reading in 1821 was 28·12 ins. December 24; and we had 28·33 at 11 a.m. December 4, 1876.

As regards the rainfall, the subjoined figures will show how much worse off we are now than our fathers were in 1822. The actual figures for London for the respective periods are—

	1821 2.	1876-7.	Average of 60 years. 1813-72.
November . .	4·42 ins.	2·63 ins.	2·28 ins.
December . .	4·82 „	5·82 „	1·93 „
January . . .	0·64 „	4·69 „	1·91 „
February . . .	0·98 „	1·73 „	1·50 „
Total for four months	10·86 ins.	14·87 ins.	7·62 ins.

We have, therefore, had nearly double our average quantity as given by Mr. Dines, and four inches more than fell at the same period fifty-five years ago, and attracted so much attention then. As regards extraordinarily high temperatures and successive prevalence of storms, we need hardly say that Sir E. Sabine's description falls short of our recent experience.

Now let us see what tale we have to tell of sea temperature in the autumn to compare with the experiences of Franklin and of Sabine. It is too early yet for us to have received all our information for so recent a date, as the logs of outwa d bound

ships will not reach the Meteorological Office for months to come, but thus much may be said:—Two experienced captains, who have been traversing the part of the Atlantic in question for several years back, have independently informed me that they never recollect to have met with so high a temperature of the sea water in the neighbourhood of the Azores in November as they observed last autumn. As to actual observations, Captain R. D. Lunham, a most trustworthy observer, reports 60° on November 1, nearly on the very spot where Franklin had 61° just 100 years ago.

This instance would, therefore, appear to confirm Sabine's theory. He goes on to say: "There can be little hesitation in attributing the unusual extension of the stream in particular years to its greater initial velocity, occasioned by a more than ordinary difference in the levels of the Gulf of Mexico and of the Atlantic. It has been computed by Major Rennell, from the known velocity of the stream at various points of its course, that in the summer months, when its rapidity is greatest, the water requires about eleven weeks to run from the outlet of the Gulf of Mexico to the Azores, being about 3,000 geographical miles; and he has further supposed, in the case of the water of which the temperature was examined by Dr. Franklin, that perhaps not less than three months were occupied in addition by its passage to the coasts of Europe, being altogether a course exceeding 4,000 geographical miles. On this supposition the water of the latter end of November 1776 may have quitted the Gulf of Mexico, with a temperature of 83°, in June, and that of January 1822 towards the end of July with nearly the same temperature. The summer months, particularly July and August, are those of the greatest initial velocity of the stream, because it is the period when the level of the Caribbean Sea and the Gulf of Mexico is most deranged. If the explanation of the apparently very unusual facts observed by Dr. Franklin in 1776 and by the *Iphigenia* in 1822 be correct, how highly curious is the connection thus traced between a more than ordinary strength of the winds within the tropics in summer, occasioning the derangement of the level of the Mexican and Caribbean Seas, and the high temperature of the sea between the British Channel and Madeira in the following winter."

It need not be remarked that it will be a matter of the highest interest and importance if we can, by observations taken on the Equator months before, draw conclusions as to the character of our coming seasons. If this should turn out to be true, we should have traced the history of our weather a few steps further back, but should not even then have discovered the absolute causes to which its changes are to be ascribed. We

should simp'y be gaining early information, without prophesying at all.

In this connection I may mention, without in any way pledging myself to its correctness, an opinion which has repeatedly been stated, and of late has been cited by one of the ablest scientific men in Australia, that the weather of those colonies appears, as he says, to follow in the wake of European weather: that a wet winter here means a wet winter for them during our summer. This seems to be rather inexplicable unless on the hypothesis that other influences are at work, independently of the earth's motion in her orbit; but even then there seems to be *primâ facie* no reason for thinking that the southern hemisphere should generally follow the northern instead of preceding it.

So much, then, for forecasting weather on a grand scale; and we must say that from one point of view it is fortunate that nothing of the kind has yet been attempted. If we were able now to furnish any grounds for an estimate of the probable yield of the chief corn-producing countries at the coming harvest, the lives of meteorologists would be a burden to them from the constant applications to them from corn merchants and others as to their prospects of successful speculation. I do not for one moment mean to say that it may not be possible, say in India, to form highly valuable predictions of the probable character of a coming season, and so to anticipate famine; but in this changeable climate any idea of the kind is utterly Utopian in 1877.

Let us now turn to the subject of what are ordinarily termed weather forecasts, the practical manifestation of which is the issue of storm warnings to seamen and farmers.

When Le Verrier proposed to Sir G. Airy an international system of storm warnings, he used, in a letter dated April 4, 1860, the following words:—

"Signaler un ouragan dès qu'il apparaîtra en un point de l'Europe, le suivre dans sa marche au moyen du télégraphe, et informer en temps utile les côtes qu'il pourra visiter, tel devra être le dernier résultat de l'organisation que nous poursuivons."

This is a far more modest prospectus than that of the unofficial weather prophets of the present day, who announce for days beforehand the changes which are about to supervene, and even in some cases the precise number of hours of fine weather which may be expected on the day following their prophecy.

Admiral Fitz-Roy also was not content with Le Verrier's programme, but announced his readiness to forecast the weather for three days in advance. A signal hoisted by his orders indicated a probability of a gale occurring within the next three days at the actual part where it was hoisted. Accordingly

when the results of his system are compared with those obtained at the present day, the fact of the utter dissimilarity of the two methods of warning is entirely ignored. At the present time the signals only cover the period of forty-eight hours, but they are held to be justified by the occurrence of a storm anywhere in the neighbourhood of the place where they are exhibited. It is therefore clear that the two systems are not, in the slightest degree, intercomparable.

If we look at our present position as regards storm warnings, and compare it with Le Verrier's proposal of sixteen years ago, we see that that still describes very fairly the extent of our weather knowledge.

When we see that a disturbance of the atmosphere actually exists, we can issue intelligence of the fact to the districts likely to be affected by it, and the value of such warnings depends on the correctness of the ideas formed by us as to the character and extent of the disturbance itself—by this is meant particularly the point or points whence the wind will blow, the force which it will exert, and the area it will cover—the direction of its advance, and the rate of its motion.

On all these points there prevails as yet a great amount of uncertainty; but that, on the whole, a satisfactory result of the system is achieved appears from the fact that a total percentage of success of warnings of strong winds exceeding 75 has been maintained for the last four years, while of actual severe gales following warnings the percentage is as much as 44.

It therefore appears that warnings are more astray on the ground of over-precaution than of negligence; but yet it would be absurd to deny that in almost every year some of our very severest gales have come on us suddenly and swept much of the coasts before any warning has been issued.

This is mainly owing to the fact that the funds available for the purpose will not allow of sufficiently frequent communication between the outposts and head-quarters, and that much time is always lost in the necessary telegraphing to and fro.

It has repeatedly been urged on us that we should institute a regular service of telegrams from America, but we had for some years such a service with Newfoundland, and derived little benefit from it. What would really be of value to us would be that a thoroughly competent meteorologist on that side should telegraph daily a general *résumé* of the weather prevailing on the Atlantic seaboard of the States, with intelligence of any disturbances leaving them which showed signs of an intention to cross the herring-pond. This has been attempted of late, with some measure of success, by the "New York Herald," which prophesied a storm on our coasts for

February 19, a prediction which was amply fulfilled, but not at all in the way at first anticipated by those who read the telegram here, for the gale was from the northward, while the wording of the message would have led us to anticipate a southerly gale.

Since that date several other telegrams have been received which have, for the most part, met with fulfilment in a greater or less degree, but have all possessed the same capital defect for practical purposes, that they have been too vague as to date, and have given no hints as to the direction whence the gale would blow.

Both of these are most important particulars; as to the direction of the gale, a doubt on this head may make all the difference in deciding whether or not such an anchorage will be safe; as regards precise time, a warning hoisted too soon may make a coaster miss his chance of a short run, or cause a fisherman to lose his night's earning. In either case the system falls into discredit, and the warning is disregarded when next hoisted; "Wolf! wolf!" having been cried too often.

The non-seafaring public have very little notion of the different lights in which warnings are regarded in seaport towns and among ordinary landsmen. In some ports which could be named the system is not in operation because the authorities think the signals would frighten the fishermen. At one place the flymen of the town succeeded in putting down the warning system, because none of the visitors would take a drive while the signal was flying; and lastly, at all places the interest of the shipowner, and to some extent of the captain, is against the warnings, for the fact of the exhibition of the signal is sufficient to make the sailor plead stress of weather, and betake himself to the public-house bar.

It appears therefore that it is not a simple question of announcing to every port in the kingdom the weather which is coming; but yet, through evil report and good report, the system established by Admiral Fitzroy has made good its footing, and is steadily growing in popularity and usefulness.

We have mentioned warnings for agricultural purposes, but our space will not allow of our treating this question at any length. They are in full operation in the United States, but there the area covered by the telegraphic system is so much larger than in Western Europe—irrespective of the fact of the system being military, and provided on a most liberal scale with funds—that the results attainable there furnish no precedent for us.

Warnings of this nature were organized in France last year, but we have not as yet seen any results of the system. The great difficulty here is to insure that the message comes to the

knowledge of the farmer. As the cost will not allow of the mountain, or the telegram, going to each individual Mahomet, it only remains for Mahomet to go to the mountain, or the nearest telegraph office, every day, and "govern himself accordingly," to use Mr. Ayrton's phrase. The question in such a case is, Is the play worth the candle in our uncertain climate?

REVIEWS.

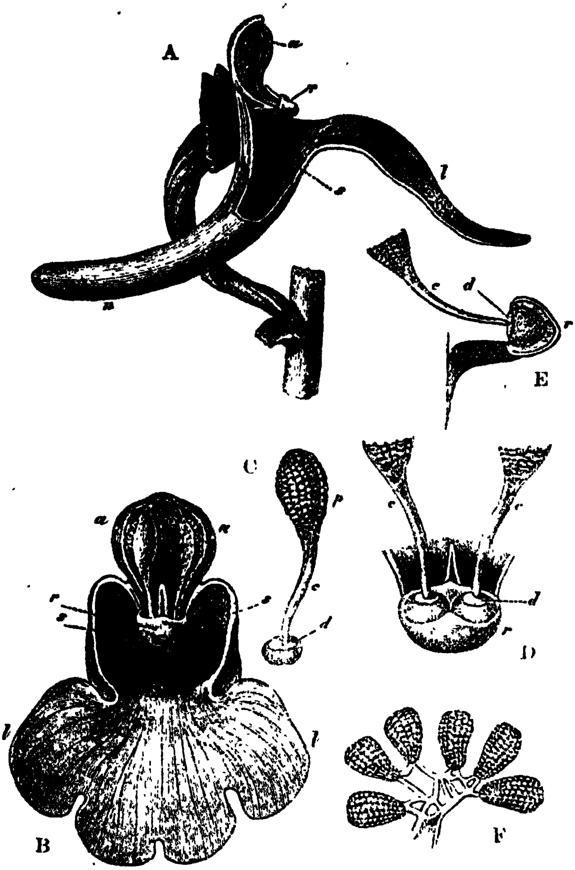
THE FERTILIZATION OF ORCHIDS.*

AMONG the points raised by Mr. Darwin in his celebrated work "On the Origin of Species" was the doctrine of the necessity of frequent or occasional cross-fertilization in the case even of plants whose flowers contain both stamens and pistils within the same set of envelopes. Several interesting cases in illustration of this principle were subsequently brought forward by Mr. Darwin himself; and in our last number we called attention to the publication by him of a most important series of observations in which the beneficial effects of such intercrossing, usually effected in nature by insects, were demonstrated beyond a doubt; but the first independent work in which the subject was treated by Mr. Darwin, was his treatise on the fertilization of orchids published in 1862, a second edition of which, embracing the later researches of the author, and the results obtained by many other observers, has lately appeared. Although this is only a second edition, the interest attaching to the subject, and the length of time that has elapsed since the appearance of the first edition, induce us to give a somewhat lengthened notice of it.

Whilst there was much *à priori* probability in the assumption that the occasional cross-fertilization of hermaphrodite flowers was a law of nature, a probability which received strong support from the observations of Mr. Darwin and others upon various plants, and the part played in the process by insects was not very doubtful, seeing that in most cases the influence of the wind could hardly be involved, and it is a matter of daily experience that flower-haunting insects are constantly dusted with pollen which they must necessarily convey from one flower to another, it was still a matter of considerable interest to find some plants in which this method of fecundation was a demonstrable necessity. Curiously enough the absolute evidence required was first obtained by the study of a group of plants in which the flowers are so singularly constructed that the stamens and pistils appear to form a single organ, and in which therefore the conditions for self-impregnation might at the first glance be supposed to be especially secured. In the orchids, in fact, the two cells of the usually single anther are imbedded in a portion of the pistil which stands up above the effective stigma, the whole

* "The Various Contrivances by which Orchids are fertilised by Insects." By Charles Darwin, M.A., F.R.S. A Second Edition, revised. Sm. 8vo. London: John Murray. 1877.

FIG. 1.



STRUCTURE OF THE FLOWER IN ORCHIS MASCULA.

The small letters throughout indicate the same parts, viz —*a*, anther; *r*, rostellum; *s*, stigma; *l*, labellum; *n*, nectary; *p*, pollinium or pollen-mass; *c*, caudicle of pollinium; *d*, viscid disc of pollinium.

A. Side view of flower, with all the petals and sepals cut off except the labellum, of which the near half is cut away, as well as the upper portion of the near side of the nectary.

B. Front view of flower, with all the sepals and petals removed, except the labellum.

C. A single pollinium or pollen-mass, showing the packets of pollen grains (*p*), the caudicle (*c*), and viscid disc (*d*).

D. Front view of the discs and caudicles of both pollinia within the rostellum, with its lip depressed.

E. Section through one side of the rostellum in a direction from front to back of the flower, with the included disc and the caudicle of one pollinium.

F. Packets of pollen-grains, bound together by elastic threads, which are here shown as stretched.

*** For the use of these and the following illustrations we are indebted to the kindness of Mr. John Murray.

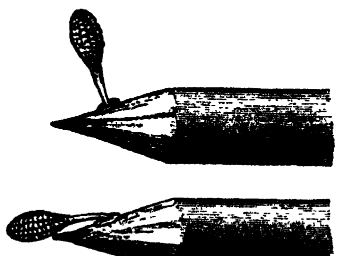
forming a body which received from the older botanists the name of the "column," and although, in some cases, these flowers are self-impregnating, fertilization is always effected by the escape of the contents of the anther cells from the cavities in which they were imbedded, before their contact with the stigmatic surface. This, indeed, was understood by Sprengel and some other old botanists, but it was reserved for Mr. Darwin to demonstrate clearly the process by which the fecundation is performed. The description of what takes place in the common orchis (*Orchis mascula*) will serve to explain the general nature of these curious phenomena.

In *Orchis mascula*, the well-known Purple Orchis of our meadows, the stigma is a bilobed viscid surface situated on the front of the pistil (*s*, in fig. 1), immediately beneath a projecting, pouch-like process (*r*) called the "rostellum," above which is the anther (*a*) consisting of two separate cells, each containing a coherent mass (*p*) of pollen, or "pollinium." The pollinia, which, when mature, are exposed by a longitudinal slit in the cells containing them, are composed of a number of wedge-shaped packets of pollen-grains, united by exceedingly elastic, thin threads (see fig. 1, F), which combine towards the lower part of each pollinium, to form a straight elastic stalk (*c*), the "caudicle." The lower extremity of each caudicle is attached to a small disc of membrane (*d*) forming part of the superior and posterior covering of the rostellum. The latter is a nearly spherical projection, which, at an early period of its growth, consists of a mass of polygonal cells, which soon become converted into two balls of extremely viscid, semi-fluid matter, destitute of all structure, lying quite freely within the rostellum, except at the back, where each of them adheres to one of the small, membranous discs (*d*), already mentioned as having the caudicles of the pollinia attached to them on their upper surface. These discs are at first continuous with the rest of the membrane enclosing the rostellum, but the slightest touch suffices to cause this membrane to split in certain definite lines, when, if the membrane of the front of the rostellum is pushed down, the two viscid balls which it enclosed are at once exposed.

This is the mechanism; its mode of action is as follows:—"Suppose an insect," says Mr. Darwin, "to alight on the labellum, which forms a good landing place, and to push its head into the chamber at the back of which lies the stigma, in order to reach with its proboscis the end of the nectary. Owing to the pouch-formed rostellum projecting into the gangway of the nectary, it is scarcely possible that any object can be pushed into it without the rostellum being touched. The exterior membrane of the rostellum then ruptures in the proper lines, and the lip or pouch is easily depressed. When this is effected, one or both of the viscid balls will almost infallibly touch the intruding body. So viscid are these balls that whatever they touch they firmly stick to. Moreover the viscid matter has the peculiar chemical quality of setting, hard and dry, in a few minutes' time." The same effects may be produced by pushing the pointed end of a pencil in the direction of the nectary; the viscid balls immediately adhere to it, and as the anther-cells are already open in front, the withdrawal of the pencil or of the insect's head, at once removes one or both of the pollinia, which may be pulled out, firmly cemented to the object and sticking up from it like horns (fig. 2, A), and owing to the position which they occupied in their cells, they diverge a little from each other when thus extricated. It is clear that if an insect after

plundering the nectary of one flower, flies away to visit another, it will insert the pollinium or pollinia that it may have extracted from the first into the corresponding part of the second, and, as Mr. Darwin remarks, the attached pollinium would simply be pushed into its old position, entirely avoiding the stigma, which is situated immediately below. To get over this difficulty one of the most remarkable "contrivances" of the whole series comes into play. It is described as follows by Mr. Darwin:—"Though the viscid surface," he says, "remains immovably affixed, the apparently insignificant and minute disc of membrane to which the caudicle adheres is endowed with a remarkable power of contraction, which causes the pollinium to sweep through an angle of about ninety degrees, always in one direction, viz., towards the apex of the proboscis or pencil, in the course of thirty seconds on an average. The position of the pollinium after the movement is shown at B in fig. 2. After this movement, completed in an

FIG. 2.



POINT OF A PENCIL WITH POLLINIUM OF ORCHIS MASCULA ATTACHED TO IT, IN TWO POSITIONS.

A. The position of the pollen-mass when first attached.
B. Its position after the act of depression.

interval of time which would allow an insect to fly to another plant, it will be seen by turning to the diagram (fig. 1, A), that if the pencil be inserted into the nectary the thick end of the pollinium now exactly strikes the stigmatic surface." The viscidity of the surface of the stigma causes the pollinia to adhere to it; but the peculiar composition of the latter, consisting as they do of numerous packets of pollen-grains held together only by slender threads,* renders the breaking up of the pollinium an easy matter. Hence only a small quantity of the pollen-grains remains attached to the stigma, and thus a pollinium attached to the head of an insect may be applied successively to several stigmas and fertilize them all. Mr. Darwin says that he has often seen the remains of the pollinia of another species of *Orchis* "adhering to the proboscis of a moth, with the stump-like caudicles alone left, all the packets of pollen having been left glued to the stigmas of the successively visited flowers."

Of the reality of this process no doubt can be entertained. The actual phenomena of the removal of the pollinia may be produced experimentally,

* It is evidently to the degree of coherence of the pollinia, and not, as Mr. Darwin seems to think, to the degree of viscidity of the stigma, that the breaking up of the former is to be ascribed.

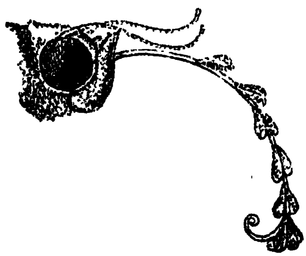
as already indicated, by the insertion of some suitable pointed object into the orifice of the nectary in the common purple orchis; after their removal the change of position may be directly observed; the fact that the whole of these operations are effected in nature by the agency of insects, is demonstrated by the frequent presence upon their heads and proboscides of the pollinia of various species of orchids; and these facts, coupled with the position assumed by the pollinia when thus attached, adapting them for being brought into direct contact with the stigmas of other flowers, and with the impossibility in most species of the pollen reaching the stigma by any other means, may be regarded as furnishing an irrefragable body of evidence, from which we may with no great difficulty infer that the whole of these contrivances, so wonderfully correlated as they are, are directed to one special object, namely the fœcundation of one plant by the pollen of another. For the advantages gained by the intercrossing of distinct individuals of plants, the reader may consult Mr. Darwin's book, "On Cross and Self-fertilization," noticed in our last number, in which one side of the question at all events is thrown into high relief; perhaps the broadest and most general effect of this intercrossing of individuals of the same species is to keep the species "true," by its tendency to efface indifferent individual variations.

But whatever opinion we may form as to the purpose in nature of this apparent necessity for at least an occasional intercrossing of individuals of the same species of plants, there can be no doubt that in nearly all the orchids we find what may be called most careful provisions made to secure that the fertilization of the ovules in a given ovary shall not be effected by the pollen of the same flower, nor in a general way, by that of the same plant. The number of known self-fertilizing species is very small; they will be found referred to in Mr. Darwin's book. In all the rest the flower shows "contrivances," as Mr. Darwin calls them, for securing the removal of the pollinia by insects visiting the flowers, although the precise nature of these arrangements is by no means the same in all.

Several species of *Orchis* show the same arrangements as *Orchis mascula* just described, and it would appear that bees, humble-bees, and flies are the chief agents in transporting the pollinia of these species. In the Pyramidal Orchis (*O. pyramidalis*) the general arrangement of the parts is very similar to that which occurs in *O. mascula*, but the caudicles of the pollinia, instead of being attached to two separate membranous discs separated from the upper and posterior surface of the rostellum, are affixed to a single saddle-like piece, representing the two discs above mentioned united, and this, which is also strongly viscid beneath, not only adheres by its under surface to the object that sets it free by pushing down the pouch of the rostellum, but actually clasps and embraces the object, which, in nature, is usually the proboscis of some moth or butterfly. This clasping not only aids in fixing the pollinia to their means of transport, but also serves to produce a divergence of the pollinia, which, by this means and by the subsequent contraction of the membrane (as in *O. mascula*), are brought into a proper position for contact with the stigma of another flower. The moths and butterflies which frequent these flowers, are actually compelled to insert the proboscis into the nectary in such a direction as will bring them into contact with the rostellum, by means of certain guiding plates placed on the labellum, and in

this way as they go from flower to flower, they often accumulate two or three or even more pairs of pollinia. One specimen of a noctuid moth (*Acontia luctuosa*) had no fewer than seven (see fig. 3), and a specimen of a *Caradrina* eleven pairs of pollinia attached to the proboscis. "The proboscis of this latter moth," says Mr. Darwin, "presented an extraordinary arborescent appearance. The saddle-formed discs, each bearing a pair of pollinia, adhered to the proboscis, one before the other, with perfect symmetry; and this follows from the moth having always inserted its proboscis into the nectary in exactly the same manner, owing to the presence of the guiding plates on the labellum.. The unfortunate Caradrina, with its proboscis thus encumbered, could hardly have reached the extremity of the nectary, and

FIG. 3.



HEAD AND PROBOSCIS OF ACONTIA LUCTUOSA, WITH SEVEN PAIRS OF THE POLLINIA OF ORCHIS PYRAMIDALIS ATTACHED TO THE PROBOSCIS.

would soon have been starved to death. Both these moths must have sucked many more than the seven and eleven flowers, of which they bore the trophies, for the earlier attached pollinia had lost much of their pollen, showing that they had touched many viscid stigmas."

From the examples furnished by these common British orchids, the reader may understand the general principle upon which the fertilization of the seeds is effected in the plants of that family. The process throughout is the same, modified in certain details, but always, except in the few species known or supposed to be self-fecundating, involving the attachment of a disc, forming part of the rostellum and bearing pollinia, to some part of the head of an insect, which thus conveys the fertilizing agents to other flowers. We shall not attempt, nor indeed would our space permit us to follow Mr. Darwin through his description of the details of the process in the various groups of orchids; for while any such attempt could only prove a failure, it might also have the effect of inducing our readers to avoid the perusal of one of the most charming natural history books that ever issued from the press. Otherwise we should have liked to give some account of the case of *Catasetum*, one of the most curious and interesting of the whole, in which the pollinia, attached to a common pedicel, which in its turn is attached to a viscid disc, are actually, as it were, shot out, disc forwards, as soon as any object comes in contact with the tentacle-like organs which here represent the rostellum. The whole of that portion of Mr. Darwin's book which is devoted to the description of the observed phenomena will be read with the greatest pleasure by everyone possessing some taste for

natural-history studies, and its perusal will open up a treasury of fresh interest for those who have the opportunity of practically following out the course of observations detailed in it.

The volume, moreover, contains dissertations upon various questions which arise naturally from the consideration of the phenomena to which we have briefly and very imperfectly called attention, questions which must possess great interest for the scientific botanist, such as the actual homological explanation of the structure of the flowers in the group of Orchids, the gradations in the mode of development of their various organs, the effects of the recognition of these gradations upon the phylogeny of the group, and the mechanism by which the peculiar phenomena of their fecundation are brought about. To enter upon any detailed exposition of the results of Mr. Darwin's investigations in these various directions would occupy much more space than we have at our disposal, and we must therefore refer the botanical reader to the book itself, which is certainly one of the most fascinating volumes that it has ever been our lot to study.

This second edition has received very considerable additions, not only arising out of the author's own observations, but also derived from the very numerous memoirs which have been published on the subject since Mr. Darwin first called attention to the curious facts revealed by the investigation of the orchids, some fifteen years ago. The illustrations, which are nearly the same as those printed in the first edition, have received some few additions; they are very carefully selected and executed, and serve to render all the details most readily intelligible.

THOMÉ'S TEXT-BOOK OF BOTANY.*

PROFESSOR THOMÉ'S "Text-book of Botany," which, as the Editor, Mr. Bennett, tells us, is the recognized book in use in the technical schools of Germany, will no doubt meet with great and well-deserved success in its English dress. Its descriptions of structure are exceedingly clear and intelligible, and the arrangement of the subject will be found to conduce greatly to a ready understanding of the internal and external anatomy of plants, in which the student will find further assistance in the very numerous and excellent illustrations. In this and the physiological section, Mr. Bennett has closely followed the German original, appending new additional information in the form of footnotes. But in the succeeding chapter, which treats of the morphology of plants, and the classification founded upon it, the Editor has departed from this rule, and while retaining his author's treatment of the Cryptogamia, he has introduced a classification of the flowering plants in accordance with the system most generally accepted in this country. The sections on Palæophytology, and on the geographical distribution of plants, although brief, are good; and the latter is illustrated by a coloured map.

* "Text-book of Structural and Physiological Botany." By Otto W. Thomé. Translated and Edited by A. W. Bennett, M.A., &c. Small 8vo. London: Longmans. 1877.

MR. DARWIN'S GEOLOGICAL OBSERVATIONS.*

IN publishing the volume of "Geological Observations" now before us, Mr. Darwin has performed a feat parallel to that of the elder Mr. Shandy, which, as that gentleman's son tells us, was calculated to make the man in the moon beat his breast in despair, and apostrophize the "eternal Maker of all beings" to know why the moonites should be incapable of such ingenious flights. He has brought out a second edition of a book of which the first never appeared. The volume, in fact, contains a reprint, apparently without alteration, of two treatises published by Mr. Darwin shortly after his return from the exploring voyage of the *Beagle*; namely, his "Geological Observations on Volcanic Islands" and his "Observations on South America," which appeared respectively in 1844 and 1846.

Both these works have now been out of print for some time, and as the observations described in them are of the highest importance, and the books themselves are constantly referred to in all general treatises on geology, their author has certainly conferred a boon upon students, whose only chance of obtaining them was the picking up of an occasional second-hand copy, by republishing them in so convenient a form. The only thing we can wish is that, as the knowledge of the volcanic rocks has made such prodigious strides of late years, Mr. Darwin had appended to the first of these treatises such notes as would have sufficed to bring the statements contained in the text into accordance with modern views and nomenclature. The maps and illustrations are the same as in the original edition.

THE PUZZLE OF LIFE.†

THE object of the author of this little book is to furnish children with a sketch of the general facts of geology and palæontology, and the meaning of its title may be explained as follows: The various fossils which give us a notion of the succession of life upon the earth are compared to the "pieces" of a dissected puzzle, and the outline of geological facts furnishes its "framework." The idea is a happy one and will recommend itself to children; and we are bound to say that Mr. Nicols has carried out his idea remarkably well, and produced a work which will do much to spread sound notions upon the gradual development of our earth and its inhabitants to the condition in which we now see them. Here and there, in his anxiety to make a point, Mr. Nicols travels a little beyond his tether, as when he says "that it is not untrue to call coal 'compressed sunlight,'" a remark which

* "Geological Observations on the Volcanic Islands and parts of South America, visited during the voyage of H.M.S. *Beagle*." By Charles Darwin, M.A., F.R.S. Second Edition, with maps and illustrations. 8vo. London: Smith, Elder & Co. 1876.

† "The Puzzle of Life, and how it has been put together; a short History of Vegetable and Animal Life upon the Earth from the earliest times, including an account of Prehistoric Man, his weapons, tools, and works." By Arthur Nicols, F.R.G.S. Sm. 8vo. London: Longmans. 1877.

requires to be taken with many grains of a salt which will hardly be at the command of his youthful readers; and when he proposes to give to "black-lead" the name of *Eodendron*, or the "dawn plant." The application of the term "Lilliputian giants" to the Foraminifera is an absurdity which we hope the author may have a speedy opportunity of getting rid of, with some others, in a new edition. The illustrations are of the ordinary character in elementary geological books, and neither good nor bad in their execution, but we would suggest that it is not desirable to figure an Ammonite from the Inferior oolite as a Cretaceous fossil; and that the skeleton of the mammoth would look better with jointed toes in his feet than with blocks of wood, especially when his living outline is indicated *en silhouette.* On the whole, however, we can safely recommend Mr. Nicols' little book as one that will have a most beneficial effect in opening the minds of its young readers.

THE HISTORY OF LIFE ON THE EARTH.*

THE youthful student, after mastering the contents of Mr. Nicols' little book, may, if he feels that way inclined, continue his studies in the same direction under the guidance of Professor Alleyne Nicholson. That gentleman's "Ancient Life-history of the Earth" in fact covers precisely the same ground as the elementary work just noticed, although of course the subject is treated in a much more scientific fashion, and in much greater detail.

Dr. Nicholson's book, although at the first blush it might seem to be merely a *réchauffé* of his "Manual of Palæontology" served up in a new dish, and with a different arrangement of the parts (a sort of publication to which we are pretty well accustomed nowadays), is in reality a new book, and one which will be exceedingly useful to students, and especially to those who are carrying on geological and palæontological investigations in more or less isolated situations. The great body of the work consists of a history of the different formations of the earth's crust, as illustrated by their fossils; and in preparing this, as a matter of course, the materials contained in his "manual" must have stood in him good stead; but the stratigraphical mode of arrangement of these materials has compelled the author to give a general sketch of the characters and subdivisions of each of the great geological formations; and these successive sketches, although necessarily very brief, convert his present work into a manual of stratigraphical geology, distinguished from other works of the same nature chiefly by the great prominence given to the palæontological side of the subject. As an introduction also, Dr. Nicholson has given his readers an outline of the principles of physical geology so far as these are necessary for the due comprehension of the special subject matter of his book, and this appears to be written with great fairness, and with a clear appreciation of those points which may be regarded as still *sub judice.*

* "The Ancient Life-History of the Earth: a comprehensive outline of the principles and leading facts of Palæontological Science." By H. Alleyne Nicholson, M.D., D.Sc., &c. 8vo. Edinburgh and London: Blackwood. 1877.

There is one feature in this volume which we are particularly glad to see, namely, the short bibliographical summaries at the close of each section. Most elementary books seem to be written as if the authors thought that they had told everything that anybody could possibly want to know; and many a student, after exhausting the limited supply of intellectual pabulum which they present to him, must have sighed in vain for some friendly guidance to those richer pastures in which perhaps his late teacher had gathered the materials for the insufficient banquet. Of course in a small work like the present, it would be unfair to expect a complete list of the works of reference to which the student should have recourse; but our author has given a very judicious selection of them, and has even indicated in many cases where the more recent scattered papers of importance are to be found, even when he abstains from giving their titles. In every respect Dr. Nicholson's little work will be found an excellent guide to an acquaintance with the subject of which it treats. The illustrations, a good many of which are new, are numerous and good, but we once more meet with our friend the mammoth with wooden feet. It is really hard upon this unfortunate animal that he should be pictorially handed down to posterity in this condition.

HISTOLOGICAL DEMONSTRATIONS.*

IT is no great wonder that these "Histological Demonstrations" have reached a second edition, for the book, which is founded upon the lectures of Dr. George Harley, edited by Professor G. T. Brown, is one of the most useful guides that the student could have in the practical study of microscopic anatomy. The first section of the book gives an account of the methods of investigation and the instruments employed, the structure and principles of the microscope, and the mode of preparation of the objects to be examined. The authors then describe the various tissues, and their combinations in the different organs of the animal body in a healthy state; and from these they pass to that most important subject to the medical student—the investigation of the morbid conditions and products of different parts of the organism. The whole of this portion of the book seems to be very well done; it furnishes an excellent summary of the present state of knowledge, with clear directions to the student as to the best methods of seeing for himself what is here described. The concluding section of the book treats of the parasites of man and of some animals, and in the first portion of this at any rate the authors are not particularly successful, especially when they place the wingless dipterous parasite, *Melophagus ovinus*, under their group "Ixoda" because it is called a tick. The part relating to the Entozoa is more satisfactory, although rather scanty in its details. This book is very freely illustrated with woodcuts, which are for the most part good and characteristic. It has also a coloured frontispiece, representing a section of the injected molar tooth of a cat.

* "Histological Demonstrations: a Guide to the Microscopical Examination of the Animal Tissues in Health and Disease; being the substance of Lectures delivered by George Harley, M.D., F.R.S." Edited by George T. Brown, M.R.C.V.S. Second Edition. 8vo. London: Longmans. 1876.

WINDS OF DOCTRINE.*

UNDER the title of "Winds of Doctrine," which we cannot but regard as somewhat unhappily chosen, although from a certain point of view the satire of the allusion is not without its force, Dr. Elam has published an assault upon the citadel of the doctrine of evolution. The point of the title is to show that Dr. Elam considers those whom he assails "unstable as water," and in the apostolic phrase "carried about with every wind of doctrine;" and the points that he attacks are the modern theory of evolution and the doctrine of automatism which has been founded upon it by some leading scientific men of high standing. It may be remarked, however, as indicating the author's standpoint, that while both he and his antagonists derive the doctrine of automatism from that of evolution, he places the derivative first in order, which may be taken to show that his objection to the theory of evolution depends rather upon its supposed consequences than upon its own demerits.

With regard to automatism Dr. Elam, by a long series of quotations from various writers, especially Professors Huxley and Tyndall, and Mr. Herbert Spencer, succeeds, we think, in demonstrating that his opponents have pushed matters too far; and in his inability to comprehend the nature of "an automaton endowed with free will," we can most certainly sympathize with him. But with all due deference to the distinguished philosophers who have derived this doctrine of automatism, pure or modified, from the theory of evolution, we cannot think that the former is by any means a necessary consequence of the latter; and we fancy that a very great number of naturalists who believe in the origin of species by descent with modification will be found to be of our opinion. Without going in for any spiritualistic doctrine whatever, we think it quite possible to see in organised beings qualities quite incompatible with the mechanical theory of life; and in reality, with our present knowledge, it is impossible to say that that theory is the true one.

At the same time we may remind Dr. Elam, if his argument has been urged, as would appear to be the case, in the theological interest, that a very considerable section of the Christian world holds opinions which if logically carried out to their consequences involve the notion of human automatism as inexorably as the materialistic conception against which he has couched his lance; and in fact that the very notion of a personal deity, unless we choose arbitrarily to abridge his attributes, may easily be shown to be incompatible with human free-will. But, as Prof. Huxley says, in one of the passages quoted by Dr. Elam:—"Why trouble ourselves about matters of which, however important they may be, we do know nothing and can know nothing?" These matters have been discussed in all times; in fact if we are to believe Milton, even the devils discoursed of fate, free-will, and foreknowledge, before man made his appearance on the face of the earth, though what possible interest devils could feel in such questions is

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* "Winds of Doctrine: being an Examination of the Modern Theories of Automatism and Evolution." By Charles Elam, M.D. 8vo. London: Smith, Elder & Co. 1876.

rather hard to see. We will therefore leave them to Dr. Elam and his opponents, with the expectation that their discussion will be about as easily terminated and as profitable as the celebrated dispute, recorded by the learned Slawkenbergius, between the Catholic and Lutheran doctors of Strasburg with regard to the reality of the courteous Diego's long nose.

A question scarcely less puzzling than those just alluded to is that of the origin of life and of organizable material, and here again our author falls foul of Prof. Huxley. To some of the arguments used by the latter Dr. Elam replies as follows :—"It is in no sense true that protoplasm 'breaks up' into carbonic acid, water and ammonia, any more than it is true that iron, when exposed to the action of oxygen, 'breaks up' into oxide of iron. A compound body can only break up into its constituent parts; and these *are not* the constituent parts of protoplasm. To convert protoplasm into these compounds requires an amount of oxygen *nearly double the weight* of the original mass of protoplasm; every 100 lbs. of protoplasm would require 170 lbs. of oxygen. Again :—"Under no 'possible conditions,' can carbonic acid, water and ammonia, when brought together, 'give rise to the still more complex body, protoplasm.' Not even on paper can any multiple, or any combination of these substances, be made to represent the composition of protoplasm, much less can it be effected in practice." It must be confessed that this argument looks very strong, and perhaps as opposed to the mechanico-chemical hypothesis of the origin of life it is as strong as it looks; but at the same time although carbonic acid, ammonia and water constitute the food of plants growing at the present day, and their nourishment is effected with elimination of oxygen, we do not know what method of combination may have occurred "under certain conditions," as Prof. Huxley says, and it may be added at a certain time. What the conditions were may perhaps always remain unknown; but even if we never discover them and are thus left in the dark as to the actual origin of life upon the earth, this need not in any way invalidate the doctrine of the origin of species by evolution, which rests its claims to acceptance upon very different grounds.

In his argument against the doctrine of evolution, Dr. Elam employs with great vigour all the weapons that have been prepared to his hand by the writings of those who maintain its truth, or at any rate its probability. But it must be remarked that the publication of those writings extends over a considerable period of time, during which the views of the writers have in many cases advanced considerably, so that, except for historical purposes, it is hardly fair to quote the whole of them as expressive of their opinions. Thus the author quotes a long passage from a paper published by Prof. Huxley in 1862, in which that distinguished naturalist affirmed that the study of palæontology negatives the doctrine of evolution; and although he afterwards cites the Professor's address to the Geological Society in 1870, in which there is said to be "a clear balance in favour of the evolution of living forms one from another" among the higher Vertebrata, he passes this over slightly and proceeds again to cite opinions expressed in 1860 and 1863. The main cry, in fact, is that of want of evidence from both the palæontological and the experimental side, the latter being of course the most crucial test to which the doctrine can be exposed. We fear that the test of actual experiment will be always impossible of application, but most

decidedly the weight of the evidence from palæontology in opposition to the theory of evolution has always been greatly exaggerated. So far from there being an absence of transitional forms among fossils, every palæontologist knows that their constant occurrence is one of his greatest plagues; and there is little doubt that by tracing any group of forms with the requisite exactitude through a series of successive deposits, the most convincing proof, short of absolute demonstration, of the interdependence of the successive so-called species might be obtained. So far as geographical distribution is concerned, the doctrine of the origin of species by descent with modification is the only one that furnishes us with any rational explanation of the facts observed; and the numerous examples of species differing but slightly from each other in neighbouring but isolated situations, such as the beetles described by Mr. Wollaston from the Cape Verde Islands, which he himself, although strongly anti-evolutionist, could not believe to have been the products of separate creations, many aquatic animals in Alpine lakes, and the freshwater representatives of marine types, with many others, seem to demonstrate, so far as observation can do it, the derivative nature of the varied forms of life.

ARNOTT'S ELEMENTS OF PHYSICS.*

THIS may be called the first posthumous edition of the well known work of Dr. Arnott. A man who in his lifetime gave considerable sums of money for the advancement of Natural Philosophy, and made a present to the public of his valuable inventions by refusing to patent them, was undoubtedly one who took great interest in Physics; yet he approached the subject, as we may say, as an outsider, coming to it from the point of view of a medical man. There are decided advantages in a book written by such an author, as likely to contain more of the practical bearings of the subject than one prepared by a professed physicist; and possibly, as in this case, to range over a wider field as included in the subject. There are few works on the elements of physics which border so closely on physiology as this does in the part devoted to animal mechanics, hydraulics, and pneumatics. At the same time, however, that the public generally will find here what they want, to the professed student it would be of little use. For him its range is *too* wide, rendering necessary a too fragmentary outline of each subject; and it is written with too little accuracy for his purpose. It is indeed rather a singular spectacle to see a book on physics written by a medical man, and edited by a Professor of Logic and an eminent Toxicologist. The editors have had the assistance of Mr. Cook, formerly Assistant-Professor of Natural Philosophy at Aberdeen, in the revision and adaptation of the work; and to him is probably due the presence of several valuable

* "Arnott's Elements of Physics or Natural Philosophy." Seventh Edition. Edited by A. Bain, LL.D., and A. S. Taylor, M.D., F.R.S. Small 8vo. London: Longmans. 1876.

notes, adding to or correcting the text, but we cannot say that the result is that the work is thoroughly reliable as far as it goes, or that it contains all that we might naturally expect it to contain. A few corrections that *might* have been made it may be well to notice.

First we are told that "all molecules are not atoms, though all atoms are molecules;" and we wonder why this false statement was not expunged, as the right one is given as a note. In the section relating to heat, we have the error too often found in the explanation of Franklin's experiment, a new form of which experiment has lately been introduced to the public as a toy, under the name of "Barometer of Temperaments;" viz., that the "warmth of the hand grasping one bulb will form steam, causing all the water to pass rapidly to the other and to boil there;" whereas it is really only the expansion of the warmed air that drives it *through* the liquid, and makes the latter *appear* to boil. Again with respect to the tides; it is doubtful whether any meaning can be attached to the following sentence that would make it correct: "The tide on the distant side of the earth is the effect of the centrifugal force not fully balanced by the attraction of the moon." Once more, though it is a question of physiology rather than of physics, it is more than doubtful if a man is fatigued four times as much by going upstairs, when he goes four times as slowly as another.

These instances will show that the book cannot be relied on as a standard, but the same might be said of others, and among similar works this is perhaps the best.

ANTHRACENE *

THIS is a systematic treatise on a subject which both in its scientific and technical aspects is of the utmost interest and importance. The perusal only of the bibliographical index at the end of the volume gives some idea to those who have been engaged on researches in organic chemistry of the immense amount of time, intellect, money, patience, knowledge, and experimental skill bestowed on the study of anthracene and its derivatives. Much of this labour has been undertaken without any hope of pecuniary gain, but from motives which actuate all purely scientific work, the desire to acquire and advance knowledge. Chemists, especially those who are not technologists, are too apt to regard the dependence of technology upon pure science without acknowledging the debt which science owes to technology. The immense amount of research made within the last ten years on anthracene and its derivatives, would never have been accomplished had not Græbe and Liebermann's synthesis of alizarine from a product of tar-distillation been carried out as an industrial enterprise, thus affording abundance of material to work upon. The same thing may

* "Anthracen; its Constitution, Properties, Manufacture, and Derivatives, including Artificial Alizarin, Anthrapurpurin, &c., with their applications in Dyeing and Painting." By G. Auerbach. Translated and Edited from the revised Manuscript of the Author, by W. Crookes, F.R.S. 8vo. London: Longmans & Co. 1876.

be said of much of the chemistry of the so-called aromatic compounds; it dates from the time when there was a commercial demand for coal-tar products. We do not of course wish to underrate the influence of Kekulé's theory of the constitution of these substances, without which we might still be groping in the dark. The volume before us gives the preparation, purification, and valuation of anthracene, its conversion into anthraquinone and the sulpho-acids. The various processes for the preparation of artificial alizarine are carefully described, and the difficulties involved are mentioned. The methods best adapted for preparing pure specimens in the laboratory are given, as well as those commercially practicable. According to the now accepted formula of anthraquinone, there are nine possible compounds isomeric with alizarine; and of these eight are actually known, though scarcely with sufficient accuracy. These are, anthraflavic acid, iso-anthraflavic acid, anthraxanthic acid, quinizarine, chrysazine, frangulic acid, xanthopurpurine, and isalizarine. Some of these are capable of dyeing mordanted tissues. From what is known of their constitution, it seems probable that only those derivatives of oxyanthraquinone are dyes which have two hydroxyl groups situated in the same benzole nucleus. To a student this work is suggestive of much research, but it requires that one should know something of organic chemistry to appreciate its value. An evident misprint, ferrous for ferric salts, occurs on page 157. We are much indebted to the translator for bringing into notice and making easily accessible the immense fund of scattered information collected in Mr. Auerbach's valuable work.

ZOOLOGICAL CLASSIFICATION.*

IT is not an easy task to compress a whole system of zoological classification into a volume small enough to be conveniently carried in the pocket; but this is what Mr. Pascoe has attempted to do, and it must be confessed with a very considerable amount of success, in a little work just published under the above title. As a matter of course the reader need not look for an exhaustive treatise on zoology in a book containing only about 200 very small octavo pages, and indeed the author himself makes no claim to have produced anything of the kind, his object being, as he tells us in his preface, to furnish "a convenient work of reference on the classification of the animal kingdom, and to bring the contents of the various groups under the eye in the most concise form."

This modest purpose Mr. Pascoe has certainly fulfilled in a very creditable manner. His little book is an excellent work of reference; for although, perhaps, it would not be possible for a beginner to take it up and learn much zoology from its pages, the student, as he progresses, will find it a most excellent aid in correlating the knowledge that he acquires, in determining the relations and the precise position in the animal kingdom of

* "Zoological Classification: a Handy Book of Reference, with Tables of the Subkingdoms, Classes, Orders, &c. of the Animal Kingdom, their Characters, and Lists of the Families and principal Genera." By Francis P. Pascoe, F.L.S., &c. Small 8vo. London: Van Voorst. 1877.

animals and groups of animals that he may meet with in nature or find referred to in other works, and in keeping constantly in his mind the general principles of zoological classification.

Starting with the Protozoa, Mr. Pascoe works his way upwards through the Animal Kingdom, which he divides into seven subkingdoms, the Protozoa, Cœlenterata, Echinodermata, Vermes, Arthropoda, Mollusca, and Vertebrata; or eight, if the Sponges, which, in accordance with the views of Häckel and Leuckart, he places among the Cœlenterata, are treated as a distinct subkingdom. For our own part, we cannot regard the sponges as forming either a separate subkingdom or a portion of the Cœlenterata; their affinities seem manifestly to be with the Protozoa. All these subkingdoms, and the classes and orders included in them, are briefly characterized, and the short diagnostic phrases aré generally followed by a few concise notes on the structure and natural history of the animals composing the groups. Moreover, the whole of these groups are tabulated in a manner which, although generally rather artificial, will aid the student greatly in finding his way through the labyrinth of zoological classification. Under the orders the author indicates by name the families into which they are divided, and gives a list either of the whole of the genera composing them, or of a selection of the best known and most characteristic of those groups. This last feature, although, perhaps, the lists of genera may appear like so much space wasted to a mere reader of the book, is really a most valuable addition for the purposes of the student, for, with the help of the index, it furnishes him with a sort of dictionary of some 1,500 generic names, such as may crop up and form stumbling-blocks in his path at any moment.

That we do not agree with Mr. Pascoe in all his notions of classification need hardly be stated. A zoologist who in the present day could promulgate a system with every part of which any other zoologist would be perfectly satisfied, ought to be publicly exhibited as the last and greatest wonder of the world. But in the present instance our author has greatly weakened the force of any objections that we could urge against certain parts of his book (such as that relating to the position of the sponges already referred to) by indicating generally, in doubtful cases, the existence of opinions at variance with those adopted by him; and we must remark further, that while he has evidently studied the most recent attempts at zoological classification, he has wisely allowed himself to be very sparingly influenced by some of the wilder speculations on the subject.

Here and there in his references to quite recent authors, and especially with regard to the phenomena of so-called alternation of generations, the author seems to us not to have quite realized the significations of terms, and his descriptions are in consequence more or less erroneous or obscure; but these are only small defects, and on the whole we can heartily recommend Mr. Pascoe's little volume to all students of zoology who want "a handy book of reference."

FOWNES' CHEMISTRY.*

WE need hardly do more than announce the publication of the first volume of a new edition of the late Dr. Fownes' well-known "Manual of Chemistry." It is now brought out under the sole editorship of Mr. Henry Watts, who has evidently done all in his power to render the book worthy of the high reputation it has always enjoyed as a student's text-book; in fact, so much has he added to the present edition, in consequence of the rapid advance of chemistry of late years, that the matter has become too extensive for a single volume, and the editor has been compelled to adopt the expedient (a somewhat dangerous one from a commercial point of view) of issuing the work in two parts.

The arrangement of the matter is the same as in the former editions, and the first volume, now before us, is devoted to Chemical Physics and Inorganic Chemistry. The treatise on the former set of subjects, although necessarily brief, furnishes an exceedingly satisfactory outline, more than sufficient for the ordinary requirements of the student, and embodying many of the most recent results of chemical research. The purely chemical portion, which occupies nearly four-fifths of the book, is also very good and well worked up. The editor has retained the author's original plan of placing the section treating of the general principles of Chemical Philosophy at the conclusion of that devoted to the non-metallic elements, but he has to a certain extent anticipated some of its teachings by appending to the article on Oxygen, or rather, perhaps, combining with what is said on Oxides, a brief exposition of the general laws of chemical combination, with an explanation of what is meant by chemical equivalents, and their use in representing chemical actions by equations. All these matters receive a more detailed and exceedingly philosophical treatment, in the section specially devoted to them, following those descriptions of the non-metallic elements and their compounds, an acquaintance with which and with the phenomena of their production, is undoubtedly a necessary preliminary to the due understanding of these general principles. As far as it has gone this new edition of "Fownes' Manual of Chemistry" appears to us to be one of the best, if not the best, handbook that the English student possesses.

* "Fownes' Manual of Chemistry, Theoretical and Practical." Vol. I., "Physical and Inorganic Chemistry." Twelfth Edition, revised and corrected by Henry Watts, B.A., F.R.S. 8vo. London: J. & A. Churchill. 1877.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

ANCIENT Sources of Tin.—Professor Karl Ernst von Baer, only a few days before his death, prepared a paper on this subject, which has been published in the "Archiv für Anthropologie." From the circumstance that almost all the ancient bronzes are found to contain the same proportions of the constituent metals, he is inclined to think that the use of bronze had spread from some single centre. The source of the tin used in the fabrication of bronzes found in the Assyrian and Babylonian ruins he thinks may be found in Khorassan, where the existence of the metal was revealed by some inquiries that he set on foot, having been led to the belief in its occurrence in that region by a statement of Strabo's. The tin employed in Scandinavia and the countries surrounding the Mediterranean before the discovery of the Cornish mines, is supposed by Von Baer to have been probably brought by the Phœnicians from Banca!

The Bulgarians.—According to a report in "Nature" (February 22, 1877), Professor Virchow lately communicated to the Anthropological Society of Berlin, the results of numerous craniological measurements undertaken in Bulgaria. The general type is said to be evidently not Sclavonic but Finnish, and to point apparently to an emigration from the Turco-Finnish tribes of the Oural, to the region of the Danube. Two distinct subordinate types are noticed; one brachycephalic, regarded as pure Finnish; the other macrocephalic, with a retreating forehead, strikingly resembling that of the Australian negro. The Bulgarians must have gradually adopted the Sclavonic language, and no trace remains of their original tongue.

ASTRONOMY.

Photographs of Stellar and Planetary Spectra.—It is rather singular that while American and English astronomers succeeded almost simultaneously in solving the difficult problem of estimating the rotation of the sun spectroscopically, they should in like manner have attained almost simultaneously the mastery of another difficult task. At Mr. Huggins's Observatory, arrangements have been in progress during the last two years for applying photography to the spectra of the stars. For this purpose Mr. Huggins has replaced the 15-inch refractor before used by him with a reflector 18 inches in diameter. The motion of the driving clock was found

to be not sufficiently uniform, and the services of Mr. Grubb were called in, who successfully applied to the clock the control of a seconds pendulum, in electric connection with a sidereal clock. The spectroscopic part of the apparatus was constructed with a prism of Iceland spar, and lenses of quartz. This apparatus was so arranged, that a solar or electric spectrum could be taken on the same plate for comparison with the spectrum of the star. After an extensive trial of difficult photographic processes, preference was given to dry plates. Among other advantages, a dry plate could be left in the apparatus until the following day, when a solar spectrum could be taken upon it through that half of the slit which was closed when the instrument was directed to the star. During 1876, spectra were obtained with distinct lines from Sirius, Vega, Venus, and the Moon, in juxtaposition with well-defined and well-detailed solar spectra. The American researches in the same direction have continued during a longer period. Dr. Henry Draper, of New York, well known as one of the first telescopists to obtain really useful photographs of the moon, has been engaged since the spring of 1872 making photographs of the spectra of the stars, planets, and moon, and particularly, among the stars, of α Lyræ (Vega), and α Aquilæ (Altair), with his 28-inch reflector, and 28-inch refractor. In the photograph of Vega, bands or broad lines are visible in the violet and ultra-violet region, unlike anything in the solar spectrum. Last October, Dr. Draper succeeded in taking photographs of the spectrum of Venus, showing a large number of lines. There seems in this spectrum to be a weakening of the spectrum towards H and above that line, of the same character which Draper has photographically observed to take place in the spectrum of the sun near sunset.

Singular Phenomena presented by Jupiter's Satellites.—Mr. Todd, of Adelaide, with his new 8-inch equatorial by Cooke, mounted in December, 1874, has made a very valuable series of observations of the phenomena of Jupiter's satellites during the last opposition of the planet, extending from June 13 to October 15, 1876. A very interesting phenomenon was observed more than once, independently by Mr. Todd and his assistant, Mr. Ringwood, when a satellite was on the point of occultation. Instead of disappearing gradually behind the planet, it was apparently projected on the disc, as if viewed *through* the edge of the planet, supposing the latter were surrounded by a transparent atmosphere laden with clouds. This curious phenomenon was noticed on two occasions at the disappearance of the first satellite, when it was thus distinctly visible through the edge of the disc for about two minutes before it was finally occulted. It is hardly necessary to point out that this appearance is readily explained when the theory is accepted which is described in Mr. Proctor's paper on Jupiter in our last number; but is entirely inconsistent with the theory usually adopted. Mr. Todd also bears witness to the constantly varying aspect of the surface of Jupiter. He was much impressed with some sudden and extensive changes in the cloud-belts, as though a violent storm was raging, changing their appearance within an hour or two, or even less, not only in their form, but also in their magnitude.

O. Struve's Companion to Procyon found to be an Optical Illusion.—Some surprise and disappointment was occasioned by the failure of the great tele-

scope at Washington to show the faint companion seen by O. Struve and his assistant Herr Lindemann, following the star Procyon at a distance of about 10″. The fact that recently that large telescope has shown other faint companions of Procyon, which neither Struve nor Lindemann could see, has led these observers to re-examine the subject with great care. The result has been to convince them that the phenomenon they had seen has no objective existence, but was the effect of an optical illusion, which causes them to see under certain circumstances a faint image or point of light at about 10″ distance from a bright star, and nearly in a horizontal line with it. They found this to be the case with Regulus, Capella, and Arcturus.

Orbit of Alpha Centauri.—Mr. Hind, the Superintendent of the "Nautical Almanac," having received from Lord Lindsay the result of two sets of measures of the angle of position of Alpha Centauri, made with the heliometer at Mauritius, in November, 1874, during Lindsay's expedition for observing the transit of Venus, in 1874, has attempted a further approximation to the elements of this most interesting binary. He employed the last orbit by Powell, of Madras, in forming equations of condition for the epochs of the most reliable mean results, depending on the measures of Sir J. Herschel, Capt. Jacob, Powell, and Lord Lindsay, at the same time admitting the angle for 1752·2 given by Lacaille's R.A. and Dec. The elements obtained by the solution of the equations are as follows:—

Peri-Astron Passage	·1874·85
Node	21°48′·0
Node to Peri-Astron, along orbit	59°32′·1
Inclination	82°18′·4
Angle of Eccentricity (or e = 0·6673)	41°51′·5
Semi-axis Major	21″·797
Period of Revolution	85·042 years.

"It will be remarked," says Mr. Hind, "that Lord Lindsay's measures fall exactly at the computed time of nearest approach of the component stars in the real orbit. Probably a somewhat closer representation of the observed angles and distances might be obtained by repeating the process from which the above elements were deduced, but I defer any further computation in the hope of soon receiving measures made after the passage of the peri-astron. If for the annual parallax, a mean of Henderson's value, as corrected by Peters, and that by Mœsta, be taken, giving 0″·928, we find the mass of this system = 1·79 × Sun's mass, and for the semi-axis major of the orbit 23·49." It is noteworthy that the mass here obtained corresponds closely with that deduced from the assumption that the intrinsic luminosity of the surface of the component stars is equal to that of the sun's surface, and the mean density of the two stars equal to the sun's mean density.

Rotation of Saturn.—On December 7, Professor Hall, of the Naval Observatory at Washington, observed a well-marked white spot on the disc of Saturn, below the ring. From observations made by him upon the motion of this spot, on December 7, 10, and 13, he deduced a rotation period of 10h. 15m., a result in satisfactory agreement with that obtained by W.

Herschel from observations of the successive appearances presented by a belt during the winter of 1793–94, viz., 10 h. 16 m. 0·4 s.

The New Star in Cygnus.—Professor Schmidt gives the following tabular statement of the varying magnitude of the new star from November 24, 1876, the date of its discovery, to December 15, when it was last perceptible to the naked eye:—

	m.		m.		m.
Nov. 24.	2·97	Dec. 1.	5·27	Dec. 8.	6·44
" 25.	3·03	" 2.	5·47	" 9.	6·55
" 26.	3·14	" 3.	5·65	" 10.	6·64
" 27.	3·38	" 4.	5·81	" 11.	6·71
" 28.	4·06	" 5.	6·00	" 12.	6·79
" 29.	4·74	" 6.	6 16	" 13.	6·86
" 30.	5·06	" 7.	6·32	" 14.	6·92

The Planet Mars. — M. Flammarion has published a chart of Mars, in which he has not only altered several of the features shown in Mr. Proctor's chart, but has introduced several alterations in the nomenclature. Dr. Terby, of Louvain, has expressed strong objections to both orders of change, and in particular to the fact that while M. Flammarion's chapter on the geography of the planet is based almost entirely on the researches of M. Terby, due notice has not been given of the fact by M. Flammarion. The latter, in reply, has expressed the opinion that the matter is not worth controversy; to which M. Terby has objected, not ineffectively, that results which are not worth controversy should not have seemed worth abstracting without acknowledgment. M. Terby considers Mr. Proctor's chart altogether more correct than the new one, so far as M. Flammarion's chart is new, which is perhaps not saying much. This is not the first occasion by several on which M. Flammarion has honoured other students of astronomy by borrowing their results.

The Total Eclipse of the Moon.—Mr. T. Rand Capron, in an interesting account of the total eclipse of the moon on February 27, remarks that during total obscuration the moon shone with a diffused weak copper-tinted light, and with what appeared a marked deepening of the dusky tint towards the centre of the disc. At no time was the tint absolutely dark. The loss of light was, however, during obscuration very marked. At times a crimson scarlet tint, deeper and less mixed with yellow than the copper tint, was noticed. "This last tint," says Mr. Capron, "reminded me much of a crimson glow common during aurora, and which I also once distinctly remarked—of course in a weaker degree—in the zodiacal light. The colours, when seen telescopically with a low power, were but little reduced in strength; the illuminated part of the moon coming out of a steel-grey, an effect which also took place when an occasional mist cloud passed over the moon's face."

Opposition of Jupiter.—Jupiter will be at his first station on April 20th, at 2 A.M., in opposition at midnight on June 20th, and at his second station at 3 A.M. on August 20. It may be hoped that much will be done during the interval between April 20 and August 20, to observe Jupiter with special reference to the questions which have recently been raised respecting this interesting planet.

BOTANY AND VEGETABLE PHYSIOLOGY.

Hybrid Fruit of Orange and Citron.—M. Oudemans has observed a fruit half orange and half citron. Externally it had precisely the form and colour of a citron. Internally, four of the compartments presented the colour and taste of the flesh of a citron; the other five had the qualities of that of an orange. The formation of this fruit may be explained in two ways. The tree which produced it may have been a hybrid between *Citrus medica* and *C. aurantium*. Or the flower which produced the fruit may have belonged to one of the above species, and have been fecundated, at least partially, by pollen of the other. On the first supposition the case would be parallel to that of *Cytisus Adami*. On the second, which M. Oudemans regards as most probable, we should have a fresh instance of the influence of the pollen on the fruit.—*Les Mondes*, December 14, 1876.

History of Polyphagus Euglenæ.—Dr. L. Nowakowski has published (in Cohn's "Beiträge zur Biologie der Pflanzen," Heft 2, 1876) a most interesting and important memoir upon the history of this curious microscopic vegetable parasite, a member of the group of Chytridia, the true position and nature of which have always been somewhat doubtful matters. Most of them are parasitic upon other aquatic plants, generally adhering to the surface of their component cells and sending processes into the interior. The *Polyphagus*, however, devotes its attention to those well-known flagellate infusoria, the *Euglenæ*, which it attacks when they are in the helpless, resting stage of their existence. The spores of the parasite are furnished with a variable number, four or more, of delicate, radiating filaments, one of which coming into contact with a *Euglena*, at once pierces its integument and penetrates into the contained protoplasmic mass. It then rapidly increases in size, and usually emits other filaments which stretch out in search of more victims, whilst the body of the spore also increases in proportion to the success of its rootlike processes, and in course of time becomes a "pro-sporangium." From this a sort of vesicle is pushed out, which after a time becomes a zoosporangium, and from it a cloud of zoospores finally escapes. Dr. Nowakowski has observed a true process of reproduction in these curious parasites. He finds that the individuals present two forms—one large, and generally spherical, which is the female plant; the other smaller, and more or less club-shaped, which is the male. These two forms conjugate in the following fashion:—The contents of the female plant project through an opening in its cell-wall and form an oval mass, with which one of the processes of a neighbouring male plant comes into contact, when the contents of the two mingle and a zygospore is produced, from which a zoosporangium is developed, and this gives issue to a swarm of zoospores. From his investigations the author is inclined to refer the Chytridia to the Siphomycetes.

CHEMISTRY.

Phosphorescent Organic Bodies.—M. B. Radziszewski has lately published in the "Reports of the German Chemical Society" (1877, p. 70), a memoir

in which he shows that there are certain perfectly well-defined organic bodies which shine in the dark when they are in contact with an alcoholic solution of caustic potash. These bodies are: hydrobenzamide, amarine, lophine, and the crude product of the action of alcoholic ammonia upon benzile; and to these the author now adds ("Comptes Rendus," Feb. 12, 1877), paraldehyde $(C^2H^4O)^3$, metaldehyde $(C^2H^4O)^n$, aldehyde-ammonia $(C^2H^4 < {OH \atop NH^2})$, furfurine, $C^{15}H^{12}O^3N^2$, hydro-anisamide, $C^{24}H^{24}O^3N^2$, anisidine, $C^{24}H^{24}O^3N^2$, hydrocinnamide, $C^{27}H^{24}N^2$, and hydrocuminamide. He ascribes this chemical phosphorescence to the slow combined action of the caustic potash and the oxygen of the air, and the intensity of the phenomenon is in proportion to the slowness of the action. The bodies are either polymeric aldehydes, or products of the action of ammonia on the aldehydes, from which aldehydes can be produced either directly or by the absorption of the elements of water, and it is to the slow oxidation of the aldehydes in the nascent state that the author ascribes the phosphorescence of these bodies.

Copper in Preserved Peas.—At the meeting of the French Academy of Sciences on February 12, M. Pasteur gave an account of the general results of an investigation made by him of the preserved peas ordinarily sold in Paris. Out of fourteen tins purchased at various shops ten were found to contain copper, sometimes to the amount of about $\frac{1}{10000}$ of the total weight, deducting the liquid, which always contains much less than the peas. The copper becomes fixed, especially in an insoluble state, in the solid matter of the peas, particularly in the leguminous part beneath the outer envelope. According to M. Pasteur nothing is easier than to detect the presence of copper in preserved peas. All those which present anything of the green tint of natural peas contain copper, those which are free from the metal having a yellowish tint. Although there is a difference of opinion as to the extent to which salts of copper are poisonous, M. Pasteur maintains that the practice of employing that metal to improve the appearance of preserved peas ought to be absolutely proscribed; and he suggests that if nothing more can be done the dealers in the articles so improved in appearance should be compelled to label their wares, "*Preserved peas, coloured green by salts of copper.*" He thinks, and perhaps justly, that they would find comparatively few buyers. In connection with the question of poisoning by copper we may refer to an extraordinary statement made by M. Rabuteau to the Academy of Sciences at the meeting following that at which M. Pasteur spoke as above ("Comptes rendus," February 19, 1877). M. Rabuteau noticed the case of a girl of 20 who took in the course of 142 days 43 grammes of ammoniacal sulphate of copper, and died of rapid tubercular disease *three months after taking the last dose of the poison.* The liver was analysed by M. Rabuteau, who found it to contain nearly 24 centigrammes of copper, its total weight being 1,474 grammes. Hence M. Rabuteau concludes that the salts of copper are far less poisonous than is generally supposed; and especially that it would be exceedingly rash to affirm that we have to do with copper poisoning in cases where eight or even twelve centigrammes of copper are found in the livers of persons who have died under suspicious circumstances.

Solid Carbon in Luminous Flames.—Dr. Heumann has continued his researches upon luminous flames, and in a recent memoir considers the question of the cause of luminosity in the flames of hydrocarbons, and comes to the conclusion that it is the presence of solid incandescent particles of carbon. He founds this opinion on the following proofs: the increased luminosity produced by chlorine, which, as is well known, has the property of separating carbon; the fact that a rod held in a flame gets coated with soot only on the lower side, whereas if the carbon were present as vapour it ought to be condensed by cooling, and therefore all round the body; the fact that a body when held in the flame is coated with soot, even though kept in a state of ignition; the fact that the particles of carbon can actually be seen in a flame when it is made to strike against a second flame or an ignited surface—the particles then become aggregated together to form larger masses, which become visible in the luminous mantle of the flame as so many brilliant points; the fact that the transparency of the luminous portion of a flame is not greater than that of a layer of smoke of the same thickness arising from the flame of burning oil of turpentine, which is known to be filled with particles of carbon; and that flames which unquestionably owe their origin to the presence in them of solid particles, give a shadow with sunlight precisely as do those of hydrocarbons, while luminous flames composed of gases and vapours only throw no such shadow ("Liebig's Annalen," December, 1876).

Alterations in Glass.—M. V. de Luynes finds that glass, when exposed to atmospheric action, may undergo very considerable alterations. Some glass from a skylight in the Conservatoire des Arts et Métiers, which appeared unaltered when looked at perpendicularly to its surface, showed, under certain angles, numerous striæ of remarkable regularity. When slightly heated, both surfaces of this glass exfoliated in the form of scales, the total weight of which was about $\frac{1}{12}$ of the whole weight of the glass. Analysis showed that the scales contained 77·8 per cent. of silica, whilst the unaltered glass had only 65 per cent. When a fragment of the glass was placed in hot water, the latter penetrated by fissures from the circumference to the centre of each scale. In other specimens the additional proportion of silica in the scales was approximately the same, namely, 77·6 and 78·4 per cent. against 65·8 and 68 per cent. in the unaltered glass. From the examination of his specimens, M. de Luynes has ascertained that the glass in them is hard to cut, that they act generally upon polarized light like tempered glass, and that some of the scales show distinctly coloured fringes. He thinks that the preservation of transparency even in glass so profoundly altered may lead to an explanation of the effect produced by the use of acid as a preventive of the irisation of window glass ("Comptes rendus," February 12, 1877).

GEOLOGY AND PALÆONTOLOGY.

Microscopical Examination of Sands and Clays.—At present the investigation of the minute structure of various rocks, especially those of the so-called igneous and metamorphic series, is greatly attracting the attention

of geologists; and Mr. Sorby, in his Presidential Address to the Royal Microscopical Society on March 7, 1877, has shown that similar examinations with the microscope of the constituents of sands, muds, and clays, may lead to exceedingly valuable results. The following is a slight abridgment of an abstract of his address published by Mr. Sorby in "Nature" of Feb. 22, 1877. The paper appears in full in the "Monthly Microscopical Journal."

"The scope of this subject, as treated by the author, included the identification of the true mineral nature of the various particles, and the determination of the nature of the rock from which they were originally derived; the chief aim being to trace back the history of the material to the furthest possible extent.

"After describing the manner in which the different kinds of deposits should be prepared, examined, and mounted as permanent objects, the author indicated the conditions necessary for satisfactorily seeing the various particles, and for observing their microscopic structure and optical characters. The particles of clay and the fluid-cavities in grains of sand are often so minute as to task the power of the microscope to the fullest extent, and some indeed are so small that their perfect definition may perhaps be impossible by any means at our command. The conditions under which many of the objects are visible are such that with highly convergent light and object-glasses of large aperture no dark outline is possible, and therefore they are quite invisible, but become quite distinct when the aperture is reduced to a moderate and appropriate amount. For this reason object-glasses of comparatively small aperture are far the best, since the focal point being further from the front lens, very high powers can be used in cases which are beyond the reach of lenses of large aperture.

"The author then went into much detail to show the character of the grains of quartz, mica, and other minerals derived from the decomposition of various crystalline rocks, and showed that on the whole there are many characteristic differences between the material derived from granitic and schistose rocks, consisting mainly in the form, internal structure, and optical characters of the constituent grains; the general conclusion being that a careful study of sands, muds, and clays enables us to form a very satisfactory opinion as to whether they were derived mainly from granitic or schistose rocks, or from a mixture of the two in some approximately definite proportion. It was also shown that the shape of the particles as originally derived from their parent rock is sufficiently definite and characteristic to enable us to form a very good opinion respecting the amount of subsequent mechanical or other change.

"Applying these principles to the study of particular cases, it was shown that the coarser British sandstones have been mainly derived from granite rocks somewhat intermediate in character between those of the Scotch Highlands and Scandinavia. Some of them consist of grains which have undergone scarcely any wearing, and are as angular as those derived directly from decomposed granite, unlike the blown sands of the deserts, which are worn into perfectly rounded grains.

"The finer sands are no less angular than the coarse. They are not derived from the wearing down of larger fragments, but have resulted from the

separation of the small from the large grains by the action of currents. Some fine-grained sandstones have been mainly derived from granitic rocks, but on the whole, the small particles of quartz have more commonly been derived from the breaking up of schistose rocks. Clays and shales consist to a great extent of particles identical in all their characters with those derived from the decomposition of felspars and other minerals which undergo a similar change. As a general rule we meet with many grains of sand even in clays chiefly consisting of extremely minute granules, which can easily be explained by the remarkable manner in which such material, when suspended in water, collects into small compound grains, which subside at a rate quite independent of what would be the velocity of subsidence of the separate particles if they were detached.

"The conclusions derived from a study of the characters of the separate grains are confirmed by the occurrence of what may be truly considered to be grains of granite or mica schist. We also in some cases meet with grains sufficiently large to show the characteristic structure of the still more complex rocks of which they are composed. Thin sections of some of the oldest slates in Wales are thus, as it were, a perfect museum of specimens of the rocks existing at a still earlier period, broken up and worn down into the sands which formed these very ancient slates."

The Corallian Rocks of England.—On the 10th of January last the Rev. J. F. Blake and Mr. W. H. Hudleston communicated to the Geological Society a most important paper on the Corallian Rocks of England, describing in great detail the series of deposits existing betwixt the Oxford and Kimmeridge Clays. Topographically the Corallian region is divided into five districts of very unequal size, wholly separated from each other. In the Weymouth district (I.) one section discloses 230 feet of beds between the Oxford and Kimmeridge Clays, made up in ascending order of grits, clays, marls, and oolites, gritty limestones very fossiliferous towards the top, clays and grits. Another section on the opposite side of the anticlinal shows the same development of the central limestones; but the lower series is considerably attenuated. There are hardly any corals; argillaceous and arenaceous matter, always, however, more or less mixed with lime, preponderates; but there is a rich and varied fauna, which has strong affinities with that of some of the Coralline beds of other districts. This culminates in the *Trigonia* beds, which lie towards the top of the main limestone series; above this the fauna inclines to Kimmeridgian, below to Oxfordian types. The remarkable character of the Supra-Coralline beds was noted, especial reference being made to the mineral constitution, fossil contents, and geological position of the Abbotsbury iron-ore. In the North Dorset district (II.) the thickness of the mass is much reduced, and its constitution greatly altered. Corals are still very rare, but calcareous sediment greatly preponderates, and is made up largely of comminuted shells, loosely aggregated pisolites, and rubble frequently false bedded; the arenaceous base of the Corallian series, described generally under the term Lower Calcareous Grit, is almost at its minimum in the neighbourhood of Sturminster. The central limestones contain a moderate assemblage of the usual Coralline forms, but *Cidaris florigemma* appears confined to a rubbly bed about 8 feet thick. The West Midland range (III.), extending from Westbury to Oxford, exhibits

the greatest variety, and, being classic ground, contains a larger proportion of the type forms of the rocks. The development is very unequal, and the entire group is reduced to less than 25 feet in some places; but where the sandy base is expanded, as in those districts where the escarpment faces the north, the thickness exceeds 100 feet, occasionally falling to about 30 feet in the direction of the dip, with the probability of the entire mass ultimately thinning to a feather edge. In many places true Coral Rag is largely developed, usually terminating the Corallian series in an upward direction, or at most succeeded by a very few feet of ferruginous sand. Throughout the great escarpment facing the upper valley of the Thames the lower arenaceous member predominates, though much mixed with thin-bedded sandy clays, the whole constituting a loose formation, which is capped by hard gritty limestone containing an abundant fauna, representative of the middle series, differing somewhat, on the one hand, from the Rag, with its partially Kimmeridgian character, and, on the other, from the Lower Calcareous Grit, whose affinities are, of course, Oxfordian. The beds of this district, however, are exceedingly varied. District IV. includes the Coral reef at Upware, 75 miles E.N.E. of Oxford; though the exposures are small, they are very suggestive. The limestone of the south pit is an excellent Coral Rag, but softer and more chalky than much of the Coral Rag of the West Midland district. Moreover, whilst the rock contains many familiar forms, and especially *Cidaris florigemma*, whose presence in abundance invariably indicates a distinct horizon, we also find the casts of shells, rarely or never met with in the West of England, but which appear common in some parts of the Continent, *e.g.* species of *Isoarca*, and certain species of *Opis*, which latter occur also in a portion of the Yorkshire Basin (V.) This bears 130 miles N. by W. from the reef at Upware. The Corallian beds are grouped as a belt of rocks enclosing an oval tract of Kimmeridge Clay. There is more symmetry here than in the south, and the triple division of grit, limestone, and grit, though not absolutely true in all places, is fairly accurate; most of the beds are better developed, and the contrast between the Coral Rag and underlying Oolites is strongly marked. In the Tabular Hills these Oolites constitute a double series, divided by a "Middle Calc Grit," a fact first indicated on stratigraphical grounds by Mr. Fox Strangways, and amply borne out by fossil contents. The shell beds of the Lower Limestones are, especially in their lower parts, charged with Brachiopoda and other forms of the Lower Calc Grit; whilst the Upper Oolite, on which the Coral Rag reposes, contains a far more varied fauna, though singularly destitute of Brachiopoda. The fauna of the Rag here, as elsewhere, inclines to Kimmeridgian types. In conclusion it was shown that, since the leading feature of the rock masses between the Oxford and Kimmeridge Clays is *variety*, a strict and rigid correlation is altogether impossible. Yet in spite of great local differences, producing in many places a strangely contrasted facies, there are certain features which may be deemed fairly characteristic of the several divisions. The bank-like character of most of these beds is very striking.

Possible displacement of the Earth's Axis.—In connection with certain well-known geological and especially palæontological phenomena, there has long been a growing belief among naturalists that some means must be found of explaining a change in the position of various parts of the earth's

surface relatively to the plane of the ecliptic and consequently to the great source of light and heat, the sun. The Rev. J. F. Twisden has lately communicated to the Geological Society a valuable paper connected with this subject, its purpose being, as he describes it, the discussion of the possibility of a displacement of the earth's axis of figure under the conditions indicated in a question (suggesting the possibility of a displacement of the axis of figure from the axis of rotation amounting to 15° or 20°) put to mathematicians in a passage of the Anniversary Address delivered to the Geological Society by its president, J. Evans, Esq., on February 18, 1876. Mr. Evans suggested that the occurrence of a great elevation at some part of the earth's surface might affect the geographical position of its poles. The treatment of the question is kinematical; the forces by which the elevations and depressions might be effected do not come under discussion. In determining numerically the amount of the deviation from the formulas investigated, approximate numbers seem to be sufficiently exact for every useful purpose. The conclusions arrived at are as follows:—

1. The displacement of the earth's axis of figure from the axis of rotation that would be effected by the elevations and depressions suggested in the question above referred to would be less than 10° of angle.

2. A displacement of as much as 20° could be effected by elevations and depressions of the kind suggested only if their heights and depths exceeded by many times the height of the highest mountains.

3. Under no circumstances could a displacement of 20° be effected by a transfer of matter of less amount than about a sixth part of the whole equatorial bulge.

4. Even if a transfer of this quantity of matter were to take place, it need not produce any effect, or only a small effect, on the position of the axis of figure, *e.g.* if it took place in a way resembling that suggested in the question, it would produce a displacement amounting to but a small part of 20°.

5. If, however, we suppose a deviation of the axis of figure from the axis of rotation amounting to as much as 20° to have been by any means brought about, the effect would be to cause a sort of tidal motion in the ocean, the greatest height of which would tend to be about twice the depth of the ocean. The author suggests as probable that the effect of this tendency would be to cause the ocean to sweep over the continents in much the same way that a rising tide sweeps over a low bank on a level shore.

6. The notion that a large deviation of the earth's axis of figure from its axis of revolution may be effected by elevations and accompanying depressions is at first sight an inviting way of bringing polar lands into lower latitudes, and thereby accounting for the more genial climate that is believed to have once prevailed in such countries as Greenland. The investigation by which the above results have been obtained seems to show that the desired explanation is not to be sought in the direction indicated by Mr. Evans's question. Whether there is any other agency by which a gradual displacement of the pole geographically could be effected is a question of far wider scope than that discussed in the present paper, and one which the author does not profess to determine.

The Rocky Mountains in Colorado.—Dr. A. C. Peale discusses ("Silliman's Journal," March, 1877) the geological phenomena of the Rocky Moun-

tain region of Colorado, and comes to the following conclusions as to their chronology. In very early times there was in Colorado, Archæan land rising above the Palæozoic sea. As the Carboniferous age progressed this land diminished by encroachments of the sea, due to subsidence of the land, which persisted through the Triassic, Jurassic, and Cretaceous periods into the early Tertiary. At the close of the Lignitic Tertiary period, there was a physical break, followed, at least locally, by a subsidence and subsequently by an elevation after the deposition of the Miocene strata. The elevation of the Rocky Mountains as now seen in Colorado is the result of an elevation commencing in early Tertiary time, when there was probably great volcanic activity in the region, and continuing through the Tertiary period, accelerated perhaps at the close of the Lignitic, and after the deposition of the Lower Miocene strata. Dr. Peale thinks that this elevation is still going on. The great elevation ascribed to the Colorado region in Palæozoic times is considered by Dr. Peale to be confirmatory of the generalization of Dr. Newberry, to the effect that the outlines of the western part of the North American continent were already indicated at that early period in the history of the earth.

A New Algerian Fossil Hippopotamus.—According to M. Gaudry ("Bull. Soc. Géol. de France," February, 1877), the remains of a new and interesting species of *Hippopotamus* occur in a breccia at Bone, in Algeria. The fossil bones indicate a species in which the dentition is less different from that of the pig type than that of the ordinary *Hippopotami.* It differs from the existing Hippopotamus (*H. amphibius*) by the presence of six incisors instead of four in the lower jaw, the nearly equal size of the incisors, the thicker, unchannelled, and more clearly marked enamel of these teeth, and the presence of only fine striæ, instead of strong channels, in the canines. By the number of incisors the Hippopotamus from Bone would belong to the genus *Hexaprotodon* of Falconer and Cautley, which is represented by three Indian species (*H. sivalensis, iravaticus,* and *namadicus*); but, from the fact that the teeth of the Algerian species present certain peculiarities not noticed by Falconer in those of the eastern deposits, M. Gaudry regards the former as a distinct species under the name of *Hippopotamus* (*Hexaprotodon*) *hipponensis.* M. Pomel thinks that the deposit in which these remains occur is of Quaternary age.

Hydractinia, Parkeria, and Stromatopora.—Mr. H. J. Carter publishes in the "Annals and Magazine of Natural History" for January, an elaborate paper, the object of which is to prove that the curious fossils forming the genera *Parkeria* and *Stromatopora,* and probably some others, are really the remains of Hydrozoa allied to *Hydractinia.* He indicates the characters of the *Hydractiniæ,* and describes a new calcareous form, *H. calcarea,* from the Guinea coast, where it is found incrusting small univalve shells tenanted by hermit crabs, and indicates its close approach to the species (*H. pliocena*) described in 1872 by Professor Allman from the Coralline Crag of Suffolk. He also describes a species with a siliceous skeleton (*H. Vicaryi*) from the Upper Greensand of Haldon Hill. The *Parkeriæ,* spherical or spheroidal bodies found in the Cambridge Greensand, have been described by Dr. Carpenter as Foraminifera, on the ground of their chambered structure, which starts, as in many Foraminifera, from a peculiarly chambered nucleus.

Mr. Carter maintains that the structure of the spherical coats is identical with that of the Hydractiniæ, and that the central chambered core is probably a Foraminifer on which the first incrusting growth of the *Parkeria* took place. *Loftusia*, a singular melon-shaped fossil from the Nummulitic formation of Persia, closely resembles *Parkeria* in general characters, and if the latter is to be transferred to the Hydrozoa, *Loftusia* must go with it; and Mr. Carter considers that with the assistance of a new form which he describes here under the name of *Bradya tergestina* from the Lower Chalk, the early palæozoic *Stromatoporæ*, the position of which has always been doubtful, may be brought under the same category.

Supposed Radiolaria in Carboniferous Limestones.—According to a report in "Nature," March, 22, 1877, Mr. J. D. Siddall has discovered remains of Radiolarians in the Halkin and Minera limestones. Some polished blocks of these limestones are said to show specimens of Radiolaria, beautifully preserved, and representing most of the types to be seen in the Barbadoes earth. The identification of these objects is, however, we believe still doubtful.

A New Fossil Sponge.—Mr. W. J. Sollas has described before the Geological Society a very interesting fossil sponge from the Cambridge Coprolite beds. He regards it as belonging to the group named Holorhaphidota by Mr. Carter, in which the skeleton consists entirely of siliceous spicules, united to form fibres, and describes it as characterized by the possession of an irregularly reticulate fibrous skeleton of this kind, composed of acerate spicules lying parallel to each other and to the sides of the fibre. Although these spicules are still sufficiently well preserved to be figured and measured individually, and the author is of opinion from the structure of the sponge that they were originally siliceous, they now consist of calcareous material. He indicates that a similar replacement has occurred in the case of various sponges of the genera *Manon* and *Porospongia*; and that this fact is of much interest as getting rid of the necessity of establishing for these forms a peculiar order of Calcispongiæ, composed exclusively of anomalous extinct forms resembling in structure existing siliceous types. The new fossil sponge is described under the name of *Pharetrospongia Strahani*. Some doubts are expressed by Fellows of the Society as to the supposed replacement of silica by carbonate of lime.

METEOROLOGY.

The Alveoliform Depressions in Meteorites.—M. Daubrée notices the peculiar depressions often observed on the surface of meteorites, which have been compared to the impressions left by the finger upon a soft paste. Such impressions occur in all sorts of meteorites. It has been supposed that these depressions are due to a bursting process occurring at the surface of the meteorites when suddenly heated on entering the earth's atmosphere, but none of the experiments made to test this supposition have confirmed it. M. Daubrée says that the large, imperfectly burnt grains of gunpowder which often fall in front of the mouths of cannon, present alveoliform depressions perfectly similar in form to those of meteorites. From direct experi-

ments it appears that these cavities in the grains of powder are due to the gases developed at the moment of ignition, which burst in various directions under very high pressure. This fact has been demonstrated experimentally by the mode in which the gases of gunpowder, under a pressure of almost a thousand atmospheres, act upon spheroids of zinc submitted to them. In the same way, when meteorites enter our atmosphere with the enormous velocity of 20 to 30 kilometres per second, they are subjected to very great pressure, producing energetic gyratory movements. Whirling in this way under great pressure the air tends to act like a screw-tap, and this mechanical action is in general accompanied and reinforced by the chemical action due to the combustible nature of the meteoritic rocks at high temperatures.—*Bull. Soc. Géol. de France*, February, 1877.

Parhelion at Campan.—One of those phenomena which, in more superstitious ages, would have set all that witnessed it in a state of alarm, was observed by M. Soucaze at Campan, in France, on February 5 last. The sun, at one o'clock was surrounded by an immense luminous circle, occupying about 50 degrees. At the rising and setting of the sun, when it was at about the same height above the horizon, this circle contained two exactly similar luminous points, each about three times the apparent volume of the sun, and exhibiting a sort of tail like that of a comet on the side opposite to the sun. The light of the circle was white and faint; the two mock suns displayed all the colours of the rainbow, which extended also over the whole of the tails.—*Comptes rendus*, March 5, 1877.

Great American Meteor.—On the evening of Thursday, 21st December, 1876, according to a notice in "Silliman's Journal," February, 1877, a meteor of unusual size and brilliancy passed over the States of Kansas, Missouri, Illinois, Indiana, and Ohio. Professor Newton regards it as worthy of special record in many respects, and gives the best account of it that he could compile from newspaper reports and letters. The meteor appears to have been first seen over the State of Kansas, probably as far west as the centre of the State. It passed nearly over, and probably south of the cities of Topeka and Leavenworth, when it was at an altitude of about sixty miles. Over the centre of the State of Missouri one or more explosions occurred; and shortly after crossing the Mississippi, which it did between Hannibal and Keokuk, but nearer to the former place, the meteor broke into several fragments. This breaking up continued while it was crossing the States of Illinois, Indiana, and Ohio. A loud explosion occurred as far east as Concord and Erie; in fact, according to Professor Newton, the meteor consisted of a large flock of brilliant balls chasing each other across the sky, the number being variously estimated at from 20 to 100. This flight is of peculiar interest, on account of the long continued violent disintegration. The region round Chicago was overcast, and though the clouds were remarkably illuminated, the meteor itself was not seen, nor were any sounds heard there. From St. Louis no sound is reported. But over all the centre of Illinois, between those two cities, a terrific series of explosions occurred. The sound was also heard at Keokuk, in Iowa, but apparently not elsewhere in that State. Over the northern part of Indiana the passage of the meteor was followed by loud explosions, and a rumbling was heard as far south as Bloomington, but whether due to the meteor is uncertain. Whether a

portion of the body pursued its way onward over the State of New York and out of the earth's atmosphere seems doubtful. Its path was nearly parallel to the surface of the earth, and might easily be upward in its latter part. But if the sky was then clear over western New York, the meteor would in such case certainly have been seen in that region. The path was N. 75° E., and nearly or quite a straight line, not less than 1,000 miles long. The duration of flight was variously estimated from fifteen seconds up to three minutes, but of course no one saw the body through more than a fraction of its path. It entered the air in a course differing only about 30° from the earth's motion, and was overtaking the earth. Its real motion therefore made a still smaller angle with that of the earth, but the relative velocity was so slow, probably not more than ten or fifteen miles per second, that the earth's attraction must have changed its direction greatly. Previous to the change it must have been coming from a point near and a little south of the ecliptic, in the eastern or southern part of the constellation Copernicus, but there appears to be no known meteor radiant at that time near that part of the heavens. According to the "Western Review" (February, 1877), the meteor was first observed at Hays City, Kansas, passing slowly along at an altitude of about 25 degrees above the horizon. In passing over Kansas City (Missouri), it is said to have appeared "about as large as the full moon, with a train from 25 to 100 feet long, of a reddish or orange colour, and entirely unattended with any noise or sound."

MINERALOGY.

Native Metallic Iron from Brazil.—M. A. Damour has communicated to the French Academy of Sciences (*Comptes rendus*, March 12, 1877) a notice of a native metallic iron from Santa Catharina, in Brazil, which is supposed to be of meteoric origin. The mass resembles wrought iron in appearance, can be worked with the file, and, although malleable, breaks easily when strongly bent. Its fracture is fine grained, and shows an appearance like stratification in some parts. A polished surface, when treated with acid, showed Widmanstätten's figures. Its filings, when moistened and exposed to the air, do not oxydize. The specific gravity of various fragments was found to be 7·747, 7·825, and 7·836. M. Damour describes the process of analysis to which he subjected this substance, and gives the following as the result:—

Iron	0·6369
Nickel	0·3397
Cobalt	0·0148
Sulphur	0·0016
Phosphorus	0·0005
Carbon	0·0020
Silicium	0·0001
Total	0·9956

The proportions of carbon and silicium are therefore very nearly the same as are found in the best samples of iron; and the amount of nickel is very

much greater than that met with in any known meteoric iron. To the presence of this great proportion of nickel M. Damour attributes the resistance of this iron to oxydation, and to the action of dilute sulphuric and hydrochloric acids.

In confirmation of this opinion, M. Boussingault stated that he had found that alloys of steel with 5, 10, and 15 per cent. of nickel, rather seemed to favour oxydation, and that he had seen the filings of meteoric irons containing from 5 to 7 per cent. of nickel rust very quickly under the joint action of air and moisture. But since the examination of the iron from Santa Catharina, he had prepared in his laboratory an alloy of 62 per cent. of steel with 38 per cent. of pure nickel, and found that neither the filed face of the ingot nor the filings from it ever rusted by contact with air and water.

From a statement by M. Daubrée, it appears that this native iron is exceedingly abundant in the province of Santa Catharina, where it is worked to a considerable extent, several thousand kilogrammes having been already extracted. He describes its constitution as exceedingly curious. Besides the metallic iron, it contains particles and slender veins of pyrrhotine, or magnetic pyrites, which, when dissolved in acid, leaves, besides sulphur, a black residue in little crystalline laminæ, which proved to be graphite. The surface of the mass is covered with a black crust of magnetite, and the same mineral in many cases separates the pyrrhotine from the grey iron. The origin of the masses is doubtful; but, as M. Daubrée remarks, their chemical and mineralogical characters have never yet been observed in any authentic meteoric iron.

Telluride of Gold, a new Mineral.—A pure crystalline telluride of gold has been lately discovered at Nagyáz in Hungary. It was exhibited by Professor Krenner at a recent meeting of the Hungarian Geological Society, and the name of *Bunsenite* was proposed for it.

Supposed Organic Enclosures in Quartz.—Pastor Kawall has communicated to the Imperial Society of Naturalists in Moscow ("Bulletin," 1876, No. 3), an account of the occurrence of organisms enclosed in rock-crystal. In a specimen from Ufalei, in Siberia, he found a pale green naked caterpillar with a dark head, 1·7 millim. in length, and 0·3 millim. in thickness. He regards it as probably the larva of a Tineid moth, and proposes to name it provisionally *Tineites crystalli.* Above this larva is a smaller and more contracted one, only 0·7 millim. in length. Another surface shows a third, bent caterpillar, and to the left of this two smaller ones. Besides these there were some half-dozen of small larvæ, and many brownish and greenish fragments, some of which probably represent the excrement of the caterpillars. In another crystal he finds filamentous enclosures, probably representing confervæ.

PHYSICS.

Sensitive Flames.—A new form of burner for the production of sensitive flames is described by Mr. R. H. Ridout ("Nature," xv. 119). It has the advantage of giving a very sensitive flame at very low pressures. It consists of a glass or metal tube about five inches long and five-eighths of an inch in diameter, closed at one end by a perforated cork, through which slides a piece of glass tube one-eighth of an inch in diameter, and about six inches long. One end of the smaller tube is drawn out in the blow-pipe to form a jet with an aperture of about $\frac{1}{16}$ inch; the other end is connected with the supply of gas. The larger tube being then fixed in a support, the smaller one is pushed up into it through the perforated cork, until the jet aperture is nearly level with the mouth of the larger tube; and on a light being applied, it gives a long steady flame, which is rendered sensitive by lowering the smaller tube.

By an ingenious arrangement the same gentleman has arrived at some interesting results with regard to the influence of combustion on the pressure of gas in tubes. Two parallel vertical tubes are connected by a horizontal tube containing a drop of water as an index of pressure. When gas is allowed to flow through both tubes, and one of the jets is lighted, the water moves towards the other, showing that the effect of the combustion is to obstruct the flow. A sensitive flame was found to produce greater resistance when shortened by a noise or a musical note, but this effect is produced even when the jet is not lighted.

Singing Tubes.—M. A. G. Montenot lately exhibited to the French Society for the Encouragement of Industrial Arts some experiments on metallic tubes which produce sounds when a source of heat is placed within them in a particular nodal position. A copper tube, into which a piece of metallic web, heated to redness, was introduced, produced an intense sound. Into another tube a little furnace, containing incandescent charcoal, was put, and this also produced a musical sound, which was modified according to the position occupied in the tube by the source of heat, and the length of the tube. M. Montenot regards this experiment as particularly interesting, not only from a theoretical point of view, as introducing a new element into the investigation of the cause of the sound produced by singing flames, but also because it may admit of industrial application in the production of sounds of sufficient intensity to be heard at great distances, as fog-signals on dangerous coasts.—*Les Mondes*, February 15, 1877.

A Gigantic Induction Coil.—Mr. Apps has lately constructed for Mr. W. Spottiswoode the largest induction coil yet made. It is described by Mr. Spottiswoode in the "Philosophical Magazine" for January. It has two primaries. That used for long sparks has a core consisting of a bundle of iron wires ·032 inch thick, which form a solid cylinder 44 inches long, and 3·5625 inches in diameter, and weighing 67 pounds. The copper wire of this primary is 660 yards long, and ·096 inch thick; it has a conductivity of ·93, and a total resistance of 2·3 ohms. It contains 1,344 turns, wound singly in six layers; its total length is 42 inches, its internal diameter 3·75 inches, and its external diameter 4·75 inches. The second primary, to be used with batteries of less resistance for short thick sparks, and for spectroscopic purposes, has

a core weighing 92 pounds, and 84 pounds of wire. The latter may be so connected as to be equivalent to a wire of double or six times the cross section of a single wire. The secondary coil consists of 280 miles of wire arranged in 341,850 turns, and forms a cylinder 37·5 inches long; its internal and external diameters are respectively 9·5 and 20 inches. The total resistance is 110,200 ohms. It is wound in four sections, the diameter of the wire in the two central sections being ·0095, and in the outer ·0115 and ·0110 inch. The increased section of the extremities is to allow for the accumulated charge that portion of the wire has to carry. A condenser of the size commonly employed with a 10-inch coil was found to give the best results. It consisted of 126 sheets of tin foil, 18 by 8·25 inches, separated by two thicknesses of varnished paper ·0055 inch thick. With five quart Grove cells a spark of 28 inches was obtained; 10 cells gave one of 35 inches, and 30 one of 37·5, and afterwards of 42 inches. These sparks were obtained without any difficulty. With the 28-inch spark a block of flint glass three inches thick was pierced. In vacuum tubes this coil produces illumination of great brilliancy and long duration; with from 20 to 30 cells, and a slow mercury break, the striæ last long enough to enable their forward and backward motion to be perceived directly by the eye. The appearance of the striæ, when viewed in a revolving mirror, was remarkably vivid, even when only two or three cells were employed.

Evolution of Hydrogen at both Electrodes.—According to Dr. Elsässer ("Bericht Berl. Chem. Gesellsch," January 1877), if a magnesium wire be made the anode in a decomposition-cell containing very dilute sulphuric acid, with a platinum wire as the cathode, hydrogen gas is evolved at both electrodes, though only half as much is produced at the anode as at the cathode, whatever may be the strength of the current employed. A moderately dilute solution of magnesium sulphate gives the same result, but in this case magnesium hydrate is deposited at both electrodes. The quantity of the magnesium dissolved at the anode was found to correspond exactly to the amount of hydrogen set free there, the volume of hydrogen evolved at the cathode being the same as that set free in a voltameter in the same circuit. The author believes that the positivity of the magnesium is so increased by the current that it combines not only with the oxygen set free by the current, but also with additional oxygen, thus setting free the hydrogen which was combined with the latter. He is, however, unable to explain why the amount of hydrogen thus evolved should be exactly half that produced at the cathode.—*Silliman's Journal*, March 1877.

New Deep Sea Sounding Apparatus.—M. C. Tardieu has communicated to the French Academy of Sciences the description of a new sounding apparatus invented by him. The apparatus consists of a hollow sphere of india-rubber, several centimetres in thickness, communicating with an iron reservoir, by means of a narrow tube furnished with a valve. The india-rubber sphere being filled with mercury, any increase of pressure forces into the iron reservoir a certain quantity of mercury, the return of which is prevented by the valve. When this apparatus is let down into deep water the weight of the mercury in the reservoir will serve as an indication of the pressure to which it has been subjected, and consequently of the depth attained.—*Comptes rendus*, 5 February, 1877.

PHYSIOLOGY.

The Phenomena of Digestion in the Stomach.—M. C. Richet has had an opportunity of renewing the direct observations made in America many years ago by Dr. Beaumont upon the action of the stomach. A boy, suffering from an impassable constriction of the œsophagus, was operated upon by Professor Verneuil, who performed upon him the dangerous operation of gastrotomy. The operation was successful, and established a permanent opening into the stomach, through a sound placed in which the necessary food was administered to the patient. In some respects the case was particularly important, as the complete impermeability of the œsophagus prevented any admixture of saliva with the gastric juices. M. Richet found that the stay of the food in the stomach was rather variable, but it was generally from three to four hours in the case of ordinary food, such as starchy materials, fats, and meat. With milk the stomachal digestion lasted from an hour and a half to two hours; the absorption of water and alcohol was much more rapid, as no traces of them were to be found in from thirty-five to forty-five minutes. The food does not gradually disappear from the stomach, but apparently it passes through the pylorus almost, as the author says, *en bloc*. During the first three hours of digestion the volume of the mass of food is unchanged; then, within a quarter of an hour at the utmost, the whole has passed away. Hunger is not caused simply by emptiness of the stomach; the organ is generally empty in four hours after a meal, but the sense of hunger is not felt until the lapse of about six hours.

To obtain pure gastric juice, M. Richet first washed out the stomach several times with distilled water, and then gave the unfortunate boy something tasty to chew, when by a reflex action the secretion of gastric juice was pretty abundantly produced. The average acidity of the gastric juice, whether pure or mixed with food, was found to be equivalent to 1·7 grains of hydrochloric acid per 1,000 grammes of liquid. It varied from 0·5 to 3·2 grains. Wine and alcohol increase the acidity; cane sugar diminishes it. When acid or alkaline liquids are injected into the stomach its fluids tend rapidly to resume their normal acidity, the latter being attained in about an hour. The gastric juice is more acid while digestion is going on, and the acidity increases slightly towards the end of the operation.—*Comptes rendus de l'Acad. des Sci.*, March 5, 1877.

ZOOLOGY.

Protective Mimicry in Bats.—Dr. Archer has noticed that a Brazilian bat (*Rhynchonycteris naso*) presents an example of protective mimicry, inasmuch as, during repose, it hangs from the branches of trees with its wings extended, so as easily to escape notice among the leaves. Dr. Dobson, in a letter to "Nature" (February 22), in reply to that of Dr. Archer, indicates other instances of mimicry in the same order of mammals. Thus *Kerivoula picta*, *Vespertilio formosus* and *V. Welwitschii*, although differing in several respects, and inhabiting widely separated regions, exhibit a

very similar coloration, the fur of the body being of some shade of orange-brown, whilst the wings are variegated with orange and black. The grounds for regarding this coloration as an instance of protective mimicry may be seen from the following quotation from a paper by Mr. Swinhoe. He says:—"A species of *Kerivoula* allied to *K. picta* and *K. formosa*, was brought to me by a native. The body of this bat was of an orange-brown; but the wings were painted with orange-yellow and black. It was caught, suspended head downwards, on a cluster of the round fruit of the Longan-tree (*Nephelium longanum*). Now this tree is an evergreen; and all the year through some portion of its foliage is undergoing decay, the particular leaves being, in such a stage, partially orange and black. This bat can, therefore, at all seasons, suspend from its branches, and elude its enemies by its resemblance to the leaf of the tree. It was in August when this specimen was brought to me. It had at that season found the fruit ripe and reddish-yellow, and had tried to escape observation in the semblance of its own tints to those of the fruit." With regard to the great Frugivorous bats of the genus *Pteropus*, which measure nearly a foot long, with an expanse of wing between four and five feet, Dr. Dobson says:—"Anyone who has seen a colony of these bats suspended from the branches of a banyan-tree, or from a silk cotton-tree (*Eriodendron orientale*), must have been struck with their resemblance to large ripe fruits, and this is especially noticeable when they hang in clusters from the leaf-stalks of the cocoa-nut palm, where they may be easily mistaken for a bunch of ripe cocoa-nuts. Hanging close together, each with his head bent forwards on the chest, his body wrapped up in the ample folds of the large wings, and the back turned outwards, the brightly coloured head and neck is presented to view, and resembles the extremity of a ripe cocoa-nut, with which this animal also closely corresponds in size." Of the smaller Frugivorous bats of the genera *Cynopterus* and *Macroglossus*, which feed on the fruit of guavas, plantains and mangoes, Dr. Dobson remarks that they "resemble these fruits closely in the yellow colour of their fur and in their size, so that it is very difficult to detect one of these bats when suspended among the leaves of any of these trees," but he is not prepared to maintain that these are examples of "protective mimicry."

The Nest of the Aye-Aye.—According to MM. A. Milne-Edwards and Grandidier, that curious quadrumanous mammal the Aye-Aye (*Chiromys madagascariensis*) constructs a large globular nest. A specimen procured by M. Soumagne, honorary French consul in Madagascar, and sent by him to Paris, is described as being made with much care and art at the fork of several branches of a large Dicotyledonous tree. Its outer surface is formed of large rolled-up leaves of the *Ravinala* (or travellers' tree), serving as an impermeable covering for the interior, which contains an accumulation of small twigs and leaves. The narrow aperture is placed on one side. In this respect, as MM. Milne-Edwards and Grandidier remark, the Aye-Aye resembles the lower members of the order Lemurina (such as *Lepilemur*, *Chirogaleus*, and especially *Microcebus*), which bring up their young either in holes of trees or in true nests. The nest of *Microcebus myoxinus* is described as resembling on a small scale that of a crow, being composed of small twigs interlaced, with a depression lined with hairs in the centre, in which the young repose.—*Comptes rendus*, January 22, 1877.

The Nest of the Gourami.—M. Carbonnier has studied and described the habits of several species of fishes belonging to the curious group of the Labyrinthici, the "Pharyngiens labyrinthiformes" of Cuvier, so called from the singular structure of their pharyngeal bones, which constitute on each side a labyrinthic cavity for the reception of water, serving to moisten the gills when the fish is out of its native element. The Climbing Perch (*Anabas scandens*) of India is perhaps the most generally known species of this group, but the most important one is the Gourami (*Osphromenus olfax*), an inhabitant of the fresh waters of China and India, which grows to a large size, and is highly esteemed for the excellence of its flesh. The history of its nidification, as told by M. Carbonnier, is very curious. As in the case of most if not all nest-building fishes, the labour falls to the lot of the male. M. Carbonnier placed his gouramis in an aquarium containing about 48 gallons of water, which he kept at a temperature of 77° Fahr. In a few days the bodies of the males displayed brilliant colours, and they began to pursue each other, and struggled furiously for the regards of the females. Having selected the finest male, M. Carbonnier left him in the aquarium with a female into whose good graces he seemed particularly anxious to insinuate himself. He soon commenced in one of the corners of the aquarium the formation of a frothy nest, which in a few hours was 6 or 7 in. in diameter and 4 or 5 in. high. He then rose to the surface of the water, and drawing in a supply of air, gradually emitted it in the form of bubbles, englobed by the mucous secretion of the mouth; these bubbles he collected and carried into his nest. The nest being completed, the male watched by it patiently, and whenever the female approached he displayed his brilliant colours, until at last he seized her and caused her to perform a first spawning, and these operations were repeated until all the eggs were laid. In order to raise these into the floating nest the male now adopted a singular device. Rising to the surface, he took in an abundant supply of air, and then, descending, he placed himself well below the eggs, and suddenly, by a violent contraction of the muscles of the mouth and pharynx, drove the air contained in them out through the branchial apertures, from which it issued so divided by passing among the lamellæ and fringes of the gills, that it formed two jets of a regular gaseous dust which enveloped the eggs and carried them up towards the surface. After the operation the male gourami himself looked as if he had been sprinkled with thousands of minute pearls. The number of eggs produced was estimated by M. Carbonnier at between two and three thousand, but only about six hundred of them hatched. For three days the young fishes resemble globular tadpoles, but within six days after hatching their development is completed. Then commence the paternal troubles of the male, for the young fishes, with the conceit and heedlessness natural to their time of life, immediately begin escaping from the shelter of their nest. The male, however, pursues them and drives them back by means of jets of air-bubbles, and it is not until about ten days after hatching that they are left to wander at their own will and pleasure. M. Carbonnier states that he has 520 young gouramis which were hatched in his aquarium in July last, and which at the beginning of December were from 1¼ to 2½ in. long. He seems to hint at the possibility of acclimatizing the fish in Europe, and remarks that, among

other advantages, it possesses the faculty of spawning several times in the year.—*Comptes rendus*, December 4, 1876.

Digestive Organs of the Phalangida.—M. Félix Plateau describes these organs as follows:—The digestive tube consists of a short œsophagus, followed by an immense median sac, into which open dorsally about thirty voluminous cæca, which occupy nearly all the cavity of the body; and lastly, of a short terminal intestine, which receives the malpighian tubes. The cæca opening into the middle intestine are identified by M. Plateau with the voluminous organ commonly called the liver in the true spiders, and not, in accordance with the opinions of previous writers, with the cæca at the hinder part of the sucking œsophagus of those animals. He also holds that the denomination *liver* cannot properly be applied to these organs, either in the arachnida or in the crustacea, but that their office is the secretion of the principal digestive fluid.—*Ann. and Mag. Nat. Hist.*, March, 1877.

Development of Tænia inermis.—The prevalence of *Tænia inermis* at Montpellier, Cette, and Marseilles, led MM. Massé and Pourquier to endeavour to ascertain the history of that tapeworm. They administered numerous segments of the worm to two lambs, and a calf, a rabbit, and a dog. The lambs, the rabbit, and the dog did not appear to suffer from the experiment; and when killed and examined at the end of about seven weeks, no traces of cysticerci could be found in them. The calf, on the contrary, showed symptoms of inconvenience in about a fortnight, and these increased until, two months after the administration of the joints of the tapeworm, he was in a condition that showed he could not long survive. On examining the tongue, there was found near its base on the left side a swelling about the size of a small haricot bean, under the mucous membrane. The animal was then killed, and about forty cysticerci were found in the muscles of various parts of the body, but none in the heart, brain, liver, or any of the other viscera. The cyst first observed on the tongue was nearly three-fifths of an inch long; those of the muscles were only about half this size. The cysts were clear, and allowed the heads of the future *Tæniæ* to be recognised within them; these presented the characters of *Tænia inermis*. These experiments confirm the results obtained by Leuckart, Cobbold, Ercock, and Saint-Cyr, and the author supposes that it is to the importation of cattle from Africa that the prevalence of *Tænia inermis* on the Mediterranean coasts is to be ascribed. The existence of the cysticercus in the living animal may be recognised by the presence of small tumours under the tongue.—*Les Mondes*, December 28, 1876.

Podophrya fixa motile.—A communication made by M. E. Maupas to the French Academy of Sciences (*Comptes rendus*, November 13, 1876) will be interesting to microscopists. He finds that *Podophrya fixa* belies its name, and can at pleasure pass from a fixed to a motile state and *vice versâ*; in fact, as he says, it is the most vagabond of Acinetina. Whether free or fixed, the author says, the body of the *Podophrya* is always nearly or quite spherical, with the suckers distributed pretty regularly over the whole surface, except on a small peripheral region corresponding to the part where the contractile vesicle is situated. After watching some of them for a time, M. Maupas saw the suckers slowly retracted into the body, whilst at the same time the

suckerless part became depressed, forming a furrow which eventually gave the body a reniform appearance. The surface of the groove showed what appeared to be striæ, but these were resolved by a high power into rows of little points which increased rapidly; the furrow spread so as to form a ring round the body, and its points became converted into long thin cilia which began to oscillate gently. The suckers had then entirely disappeared, and after a time the body was flattened in a direction vertical to the ciliated belt, the cilia became more active, and the *Podophrya* moved through the water, turning upon itself, but with the part where the furrow originally appeared always in front. All these changes took place in about half an hour. The period of activity varies in length, and in returning to the motionless condition the *Podophrya* passes through a series of changes the reverse of those above described; the suckers appear first, then the body shortens and becomes broader, the vibratile cilia are gradually retracted and the body rounded, and in about twenty minutes the animal resumes its globular form with its surface covered with long suckers. The same individuals passed several times through this series of metamorphoses. M. Maupas regards *Podophrya* as an intermediate type uniting the Infusoria Suctoria with the Ciliata.

Commensalism in Caterpillars.—Dr. Fritz Müller describes a curious instance of commensalism in two larvæ of some unknown Lepidoptera. He says the larger caterpillar, which has a red head, and is protected from enemies by long, branched, white stinging hairs, lives on mulberry and other trees. Like other protected caterpillars it is light-coloured and sits on the upper surface of the leaves. The second caterpillar is a little blackish fellow, and lies across the back of his larger companion, concealed among the stinging spine-like hairs of the latter. When taken off he went back to his original place immediately. In order to photograph the two animals Dr. Fritz Müller stupefied the large one with æther, which caused its death in about two days. The smaller caterpillar then quitted his post, and took up his abode on a second specimen, the place that he had occupied on his former host, having a pale and worn appearance. The smaller caterpillar stretches down from his position of vantage among the spines of the larger, and eats little holes in the leaf on which the latter rests.—*Zool. Garten*, 1877, p. 67.

Fauna of Lake Gokcha.—The study of the faunas of isolated sheets of water promises to furnish some of the most striking direct confirmations of the theory of the origin of species by descent with modification, and all records of such investigations must be regarded as of much importance. Lake Gokcha, on the fauna of which Professor Kessler has lately published a memoir in the "Memoirs of the Society of Naturalists of St. Petersburg," is one of these interesting localities, being situated in the Caucasus, at a height of 6,419 ft., and entirely surrounded by lofty mountains, through which only a small river carries off its surplus waters. Its surface occupies about 660 square miles, and its general depth varies between 150 and 250 ft., but in one part it reaches 301 ft. In this lake Professor Kessler found *Spongillæ* to be exceedingly abundant. The commonest worm is *Nephelis vulgaris*; the crustacea are represented by numerous Entomostraca, and by a single species of *Gammarus*; the Gasteropod mollusca are all well-known European species (*Limnæus stagnalis, ovatus* and *auricularius* and *Planorbis carinatus*); and the *Bufo viridis* and a local variety of the

common frog abound. With the fishes the case is somewhat different, and this fact is interesting in connection with the recent observations of M. Victor Fatio on certain species of fish in the Swiss lakes. Although the lakes swarm with fish, these belong only to five species, three of which, pertaining to the genus *Salmo*, are regarded by Professor Kessler as new, although allied to or intermediate between the well-known European species *Salmo fario*, *S. trutta*, and *S. lacustris*. Professor Kessler proposes to name them *Salmo ischan*, *hegarcuni*, and *bodschac*. Of the other two species, one very closely resembles *Capoëta fundula* Pallas, a Central Asiatic species; and the other most nearly approaches *Barbus Cyri*, de' Filippi. The last-named species inhabits the streams flowing into the lake from the mountains.

Demodex folliculorum.—Whether Butler's reference to the "maggot in cheesemonger's nose" is to be taken as evidence that the philosophers of his day had any knowledge of the existence of the curious parasite in the follicles of the human skin to which the above name has been given, is a question that we may leave to the learned in such matters, who may at the same time settle whether cheesemongers are more subject than other men to the peculiar pimples which betray the presence of the parasite. Our first definite knowledge of it is due to Dr. Simon, of Berlin, who discovered it in 1842, by the assistance of Erichson recognized its affinity to the mites (the group to which the itch-parasite also belongs), and described it pretty fully under the name of *Acarus folliculorum*. Professor Owen, in 1843, founded a new genus for the reception of the parasite, and called it *Demodex*; Erasmus Wilson, who regarded it as a worm, named its genus *Entozoon*; M. Paul Gervais, in ignorance of Professor Owen's name, gave it the generic name of *Simonea*; and M. Miescher, changing both names, christened it *Macrogaster platypus*. M. P. Mégnin, a well-known student of the Acarina, has just published (in the "Journal de l'Anatomie et de la Physiologie," 1877, No. 2) a long and interesting memoir upon *Demodex folliculorum*, containing a history of our knowledge of the animal, a discussion of its zoological affinities, a full description of its structure, and an account of its development and habits. Like its discoverer and most of the zoologists who have described it, he refers it to the order of Mites (*Acarina*), and, following M. Paul Gervais, he regards it as forming a distinct family (*Demodicidæ*) in that order, nearly related to the Bear Animalcules (*Arctisca* or *Tardigrada*), so well known to all microscopists, on account of their wonderful faculty of coming to life again after desiccation.

These creatures are minute, somewhat worm-like parasites, from $\frac{1}{120}$ to about $\frac{1}{60}$ inch in length, having a more or less oval cephalothorax, bearing in front a sort of rostrum composed of mandibles, maxillæ, palpi, and ligula, and along its sides four pairs of short, three-jointed feet, each furnished with a pair of blunt claws. Behind this part comes a thinner, finely-ringed abdomen, variable in length, but usually longer than the cephalothorax. The little animals are found in the sebaceous and hair follicles of the skin in man and some animals. They are said by M. Mégnin to be viviparous, the females producing small footless, contractile larvæ, without any mouth organs; these, shortly after their birth, acquire three pairs of conical tubercles, which serve them as feet for creeping about. A change of skin

converts these larvæ into pupæ of similar form, but having four pairs of papilliform feet, and showing traces of the rostrum. After a second change the perfect *Demodex* is produced, but still without the sexual organs, which make their appearance subsequently. M. Mégnin distinguishes three if not four forms of these parasites, which, however, he prefers to regard for the present as varieties of a single species, *Demodex folliculorum*. The commonest of these appears to be that of the dog (var. *caninus*), which inhabits the hair-follicles of all parts of the body of that animal. A smaller variety (*cati*) is found almost solely in the sebaceous glands of the ear of the cat; and a larger one (var. *hominis*) in the follicles of the human face. M. Simon also met with similar parasites in the glands of the margin of the eyelids in sheep (var. *ovis*), but no other writer has ever seen them there. In the dog the presence of these parasites, which occur in great numbers together in the hair follicles, produces a regular skin disease, or mange, but this does not appear to be transmissible to the human subject.

Intelligence of Ants.—Sir John Lubbock has communicated to the Linnean Society, a fourth part of his "Contributions on the habits of Ants, Bees, and Wasps," in which he describes the results of numerous ingenious experiments made to test the intelligence of various species of the first-named group. Individuals of *Lasius niger*, engaged in fetching larvæ out of a small glass cell, in which they passed over a somewhat complicated bridge, were at once stopped in their proceedings by the interposition of a small gap of only $\frac{3}{10}$ inch; they had not sufficient intelligence to drop this short distance, unless indeed they were deterred by prudential considerations as to the possibility of getting back, nor did those below adopt the apparently easy method of crowding upon each other to the required height to re-establish the broken communication. As an example of conscientious industry, Sir John cited the case of an individual ant, which he was in the habit of shutting up in a bottle before leaving home for the day; the little prisoner when released immediately commenced work, and even a week's imprisonment had no effect upon its zeal. From some experiments, it appears that ants when in difficulties in sight of their companions are by no means always assisted or relieved, and this is especially the case when the charms of a store of honey or other food come into competition with the promptings of the benevolent instincts. Individuals under the influence of chloroform were generally passed without notice, but sometimes even their friends would push them out of the way; the general practice was to let friends lie, but to drop strangers over the edge of the board. Intoxicated ants appeared to be a puzzle to their friends, who, however, generally picked them up and carried them into the nest; but strangers in the same condition were not so kindly used, they were thrown into the water and drowned. Sometimes mistakes occurred, strangers were carried into the nest, and friends thrown into the water; no attempts were made to save the latter, but the strangers were generally detected and ignominiously dragged out of the nest again. From various experiments it appeared that the ants of an entire nest know and recognize each other; indeed even after a year's absence, old companions are recognized and amicably received, whereas strangers are almost invariably attacked and maltreated, even when mixed with old friends. In this respect, however, different species show differences of character; *Lasius*

flavus behaves as above described, but *Formica fusca* is much milder and more courteous in its demeanour towards strangers. Some of the experiments seem to show that the sense of sight is not very acute in certain species of ants. Thus, food was placed a few inches from the nest on a glass slip, the straight road to and from which was soon learned, but when the food was shifted only a short distance from its original position, the same individual ants wandered about in a circuitous path for several minutes and sometimes for half an hour, before discovering the new locality of the food. Sir John Lubbock confirms the statements of former writers as to slavery being a regular institution with some genera of ants, and states that the Amazon ants (*Polyergus rufescens*) absolutely require a slave attendant to clean and feed them. Some of his experiments seemed to prove that these aristocratic ants would rather die than help themselves. The author also referred to certain parasites on ants and in ants' nests.

STUDIES AMONGST AMŒBÆ.

By PROFESSOR P. MARTIN DUNCAN, F.R.S.
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[PLATES V. AND VI.]

SHOULD a beginner in science wish to know what the very commonly repeated word Amœba represents in nature, he will, of course, seek for information in the numerous deep and superficial works on natural history of the day. A glance at the drawings given in half-a-dozen books will convey the impression that this creature is remarkably given to change its shape, for no two are alike; but unfortunately this unintentional truth is qualified by the fact that there is a singular want of conformity and unanimity in the written descriptions. Some naturalists will tell the inquirer that Amœba is an animal; others that it is a plant; and the very philosophical assert that it is neither, but that it belongs to the indefinite group of Protista. There is, however, a general belief that it is an exceedingly minute piece of protoplasm, being the lowest form of living thing; that it is constantly changing its shape, and protruding from one part after another, long or lobed projections called pseudopodia, with which it catches its prey; that anything over which it passes sinks in and is digested; and that it contains a nucleus, a contractile vesicle, and some vacuoles. It is usually stated that there is an outer coat with a doubtful membrane on it, and a granular inner mass which never runs into the pseudopodia. Finally, it is said to cast off its legs and divide, the separate pieces turning to perfect Amœbæ. The term "amœboid" is very constantly employed in explaining the movement, real or theoretical, of certain cells in the higher animals, and the idea is that it is a very slow, creeping, and changing one.

Described as it is, and drawn as it has been, in the books by which the young naturalist has to be taught, can there be the least reason or necessity for asking, What is the Amœba? Suppose the matter be looked into a little more deeply. It will then be found that some very admirable observers are by no

means in accord about the peculiar structure of Amœba, and that there is a great discrepancy of opinion regarding its mode of life, nature of movement, and manner of reproduction.

As the subject is important and yet by no means difficult, and as the anatomy and peculiarities of the Amœbæ can be examined by anyone possessing a good microscope and patience, the following studies have been brought forward in the order in which they were carried out, so as to assist any observer who may care to commence a similar course of investigation.

If anyone will go to Hampstead Heath, and, after enjoying the view over Harrow and Hendon, will walk down to the bottom of the valley which in summer is a mass of ferns and moss, he will find a small stream with a very boggy bank flowing at last into a pond. Here and there the running water flows over a rusty bottom, and moves long lines of confervoid growth in gentle waves. This is the home of Amœba, for there is pure well-aerated water and favourite food in abundance.

At the very outset of the investigation it is necessary to admit that Amœba comfortable, and Amœba in bodily discomfort may present very different appearances; and that a well-nourished individual, roaming in plenty of water and well supplied with air and food, will probably look very differently from one in a thin film of water with a piece of thin glass not very lightly put upon it. In fact, Amœba well fed, free, and natural, is a very different creature from Amœba cribbed, cabined, and confined, and anxious about things in general. The one moves along in a definite manner, has a meaning in its equally definite changes of form, and its life is long, and has a definite termination; the other is 'all abroad,' pokes out projections and retracts them in a most disorderly manner, and soon comes to a point in its career when its protoplasm loses its 'subtle influence,' and yet without molecular change, dies. This last is the type usually drawn in books, and it only slightly resembles the first. Then it is necessary to remember, before plunging into notes and drawings, that if the unborn young of the higher animals during their stages of growth, resemble animals simpler in construction than those which they will finally be like, some of the immature lower animals may resemble the Amœba. In other words, we must know that the Amœba-like thing we are going to work at, will always lead an Amœban life and die and reproduce Amœbas, and not turn to something else in its old age; or that it is the offspring of an Amœba. Moreover, in the study of the creature, it is necessary to speculate upon the possibility of Amœba having a romping childhood, a restless youth, and a ruminating senility; and that under the influence of exuberance of growth, the desire for amatory companionship, and the sedateness of old age, it may present many kinds of activities and

external habits. Certain it is, that when young the Amœba plays tricks and imitates some of its fellow creatures; that when middle-aged it roams about; that in its marriage two become one never to separate or part; and that late on in life it becomes rotund and quiet, and very unlike its old self.

There is generally not much trouble in finding the Amœbæ, for if they are in the water at all they are usually abundant. Their particular locality appears to differ according to the kind and age; and if for the sake of convenience they are grouped into three sets or types, one will be found in the midst of the minute miscroscopic algæ and confervæ on top of the mud; another will be noticed roaming over the tangled masses, and moving far and wide; and the third, more protean in its changes, is found everywhere on the glass, in the mud, and even floating for a moment or two in the midst of the water. Usually I have found the second kind (figs. 2, 7, 5) very common when the water and confervæ were fresh from the stream, and its activity is quite unlike what is usually called Amœban; but this very lively form, which rarely puts out long processes (pseudopodia), and the shape of which is often very sausage-like, soon becomes comparatively lazy, and permanently changes its shape into that of a disc or flat globe (fig. 8), which after leading a monotonous life increases in rotundity and bursts. It gives exit to a host of excessively minute globules, which are so many young Amœbæ.

In my first examination of some of the Hampstead water, in which some confervoid growth and a small quantity of bottom mud occurred, I used an ordinary glass slide, with a thin glass cover. There were two kinds of Amœbæ found within the field at once; one was the active form just alluded to, and the other was comparatively quiet. The quiet one may as well be noticed first, as its construction was very definite and clearly seen. It was looked at within a few minutes of its being placed on the glass, and then it presented the appearance of a ragged half-circle (figs. 9, 10) of very transparent faintly granular protoplasm, in the centre of which was a correspondingly shaped mass of granules, refractive globules, dark spots, and one or two clearish spaces of circular outline. The distinction between the two parts was evident enough, but there was no strict line between them, and on using an object-glass of one-eighth inch focus, the clear protoplasm was seen to enter between the granules and other constituents of the internal part, and indeed to be their medium. There was some slight movement on the free edge of the clear part, which may be called diaphane, and a ragged look was produced by a slight protrusion and a subsequent rounding off; and the internal mass (call it endosarc) had a motion going on within it which was peculiar. It was all edging away, so as to approach one angle of the diaphane;

then there was a movement of some of the granules and other microscopic bodies amongst the mass, like a flowing here and there, but still with a tendency towards streaming in one general direction; and the clearish circular space suddenly became obliterated, and slowly reappeared again, and enlarged. Soon the outside diaphane began to creep from the end of the endosarc, so that very shortly the Amœba assumed a relative condition of the diaphane and endosarc which was never subsequently lost (fig. 10). The endosarc reached to the edge of the Amœba in one part, and the diaphane kept to the opposite end, some slight film of it just encasing the whole, except now and then. Although the granules and other very visible matters usually kept away from the bulk of the diaphane, every now and then a rush would take place amongst them, and then the diaphane being made ragged by some projections of it, some granules would stream along towards and sometimes close to the diaphanous edge (fig. 4). The motion of the whole Amœba was in one general direction, the endosarc end being, as it were, dragged after the other. But the internal motion amongst the granules &c. immediately preceded the slow projection of a part of the diaphane; and as this was retracted, or as the whole body progressed beyond it, there was a return of the endosarc to its place of concentration. Very slow was this Amœba; and indeed, further experience, after the examination of many of them, proved that this dignified pace was more or less invariable. It never projected long processes, rarely took in food, and often rolled over most tempting things, things with which other Amœbæ are often crowded, but they did not sink into the mass and become dissolved. Its endosarc end, however, now and then adhered to minute broken-down organic matter and small diatoms, and they were dragged along with the whole. Now and then small portions were drawn in by the endosarc at one point where the diaphane was thinnest, but the proceeding was very tedious, so that the watching was long and tiresome before the green or red food was seen in and amongst the streaming and moving endosarc.

It appeared as if great care was required to take in the minute grain of food so as not accidentally to let out a quantity of the endosarc during its constant motion and streaming. The same slow process accompanied the getting rid of digested food and some minute spheres which were eventually to become Amœbæ. Then the endosarc projected so as to be covered with a very thin film of diaphane, and one of two things happened. Either some granules came close to the edge of the diaphane, and this was penetrated by a number of them (figs. 14, 15), or a very fine thread of granules pushed out a covering of diaphane far beyond the edge, and then the contents were

pushed through and the projection retracted. All this appeared to go on at one place, however, and that was the end remote from the onward moving diaphane. On a subsequent occasion, when examining this Amœba in a live box with a quarter-inch object-glass, a companion came creeping along, and as they were bound to come into collision I watched them with some interest. They touched at their diaphane ends, and it was evident that this protoplasm was not viscid, nor was it like thick gum or mucus. There was no external film or wall, but the diaphane of both creatures gave way a little, and no contraction or irritability was noticed. After a while the Amœbæ got clear of each other, and again came in contact in moving obliquely over the glass. This time the endosarc ends of both touched and expanded, and to my surprise the endosarc of one Amœba merged into that of the other, and the diaphane also. Was it cannibalism, or was it the very acme of love? The happy united, we can hardly say "pair," moved out of view gradually, and hid up amongst some shady confervæ (fig. 19). Towards the middle of August this kind of Amœba became very common, and careful watching showed that it was able to assume two phases, so to speak, of existence, one of which, as will be shown further on, referred to what the creature had been, and the other to what it would inevitably come to. With regard to the first phase, it was noticed that a small specimen, with the endosarc crowded with dark granules and minute spheres, and having a contractile vesicle, evidently had taken in minute diatoms, and had received, therefore, some pabulum, which it might expend in some physiological energy or other. The enlargement of the whole became evident, and the narrowing of the endosarc end also; but changes also occurred which were very interesting (figs. 21–25). A clear space became visible in the midst of the dark mass of granules, and it did not disappear, so it was not a contractile vesicle, but what is termed a vacuole, or water space. Then the movement of the Amœba became more active, and two blunt prolongations of the diaphane were projected, as if this clearish substance had suddenly poured out and consolidated. There were two pseudopodia, and their production was synchronous with a movement in the endosarc granules, as if these were going to flow out in the direction of the pseudopodia. The Amœba then drew in one pseudopodium, and another long one came forth on one side of it; then others followed from the same end of the creature, which began to progress vivaciously, and, in fact, to begin to lead the life of the active in-taking individuals, abundance of which existed in the aquarium.

About the same time that this change was noticed the dark endosarc of the Amœba began to be more diffused, so that the diaphane was constantly encroached upon by it; and the opaque mass

of granules became transparent here and there, so that the contractile vesicle, the vacuole, and a body hitherto unnoticed in this description, could be easily seen. This body was a globe surrounded by a dark line, in the midst of an almost complete circlet of light. On one side the little globular mass adhered to the surrounding endosarc; and elsewhere a clear fluid surrounded it and separated it from the granular mass. This is called the *nucleus*. Earlier in the season a number of Amœbæ (see series figs. 20–25 and fig. 13) had been examined which greatly resembled those of the active phase of the comparatively quiet form; and I have no doubt, after a study of sketches which were taken of them day by day, that they eventually turned into this quiet form. The end of the quiet form, which we may consider a phase in the life cycle of a thing very different-looking in its youth, appears to be two-fold, namely, a bursting or an encysting. Very considerable changes go on in the endosarc, such as the formation of large vacuoles and the development of more than one contractile vesicle, and the endosarc granules become diffused in the diaphane, to its edge. Then the whole assumes a globular form, and a sudden burst gives vent to the contents (fig. 26). Or the globular form may become perfectly motionless, or rather only the faintest wavy motion may be perceptible at the edge (figs. 29, 27), and induration of the thin film of diaphane occurs, and a kind of thin shell is formed to the whole mass. This encysted stage lasts for a few days in the glass cell, but it endures for a long time in the aquarium, and probably throughout the winter in many instances.

Keeping these changes of general shape in mind, let us consider the first active Amœba which was seen. This was a most exciting Amœba, and I confess to my astonishment at the pace the protoplasmic granular mass poured, I do not know a more significant phrase, along. It was, when first seen, in the shape of a longish cylinder, flattened at the end which moved in advance, and rather pointed at the opposite extremity, which was, as it were, dragged along (figs. 2, 7). There was no distinction between diaphane and endosarc, for the spherical granules, which were large and not abundant, were like currants in a dumpling. The diaphane was in excess, and was as usual nearly as transparent as water, tinted most faintly with neutral tint and very minutely granular. One of these transparent Amœbæ was one-fiftieth of an inch in length, and the streaming and rushing of the internal granules, and the coincident flowing out of rounded masses of diaphane (lobular pseudopodia), was constant and in every direction away from the small end. The grand current was central, and in the axis of the Amœba, and then when the granules came with a rush close to the very edge of the diaphane they turned outwards and then backwards, and on all

sides around the current, and so as to remount the outer part of the cylinder, again to be drawn into the central stream. This circulation was accompanied by liberal outflows of wonderfully transparent diaphane with rushes of granules and regressions, but the motion in the end was strongly in the one direction, namely, remote from the small end. The Amœba would expand and dilate, contract, and become sausage-shaped; and it would turn, but always with the one end first, and never with the small end in advance. So large and so active a creature resembled greatly an amœboid animalcule which has been called Pelomyxa, but it differs in many essential respects. It was a very wanderer—did not seem to settle down to take in food when surrounded with all sorts of things nice to others of its genus—and the sameness of the globular highly refractive bodies inside it was most remarkable. Evidently the constancy and the briskness of the movements, although no long processes or pseudopodia were ever projected, required a corresponding amount of sustentation. Perhaps this active Amœba was in a non-devouring phase of a complex life cycle. This last idea appears to be consistent with observation, for I traced one, through its 'fitful fever,' until it became quieter, more rotund: then at last, and to my surprise, the granular spheres collected more definitely together to form an endosarc which soon became central. Here, then, the active Amœba assumed the shape of that quiet form already described, but there was this internal difference—that the endosarc consisted of very refractive granules, globules, or spheres.

The protoplasm of the diaphane of the Amœba was undoubtedly clear, but in the mass was not so transparent as the rounded projections which were formed every now and then, but possibly this was caused by their thinness. Under a high magnifying power ($\frac{1}{16}$ immersion), a granular appearance was decidedly seen in it. A contractile vesicle was usually to be seen, and it was carried along in the moving inside. Now this shows that the comparatively clear protoplasm had a part of it severed, as it were, from the rest, and in the midst there was this curious power of opening out to form a space, and closing in with sufficient force to drive water out of it into the surrounding part. So refractive were the granular spheres which were scattered over the Amœba, within a thin film of diaphane, and so large was their central transparent part, that they resembled a host of small spaces or vacuoles, but their ultimate fate, which will be noticed further on, disproves this notion. A nucleus so faint that it can be rarely seen exists in this Amœba; but when it becomes apparent it is seen to be very transparent, and to be environed by a clear peripheral line except at one spot. In the figure (fig. 6) it is in the midst of a mass of the refractive granules.

The question of course arose, What was the early shape and what was the course of life of this very active Amœba? It could not be answered from the results of last year's work, but during the months of April and May of the present year the same stream-bottom yielded the required evidence. The smaller of these Amœbæ (fig. 28) seen moving about the confervæ and on the glass of a shallow live-cell box had all the characteristic movements of the form just described; but the minute creature had a very small end which never dilated or expanded like the opposite termination of the body, and an extremely actively moving pale endosarc. The movement was always with the broad end forwards. The bulk of the Amœba moved over things which made no impression on it, but the small end was sticky and often adhered to diatoms, and there was often a struggle between them, the affair ending in a sudden separation with a jerk. As these young forms were watched, it became evident that occasionally a minute spore or small navicula-like diatom coming in contact with the spot where the sticky end joined the non-adhering protoplasm of the diaphane, sank into the body, and was soon seen streaming along inside, environed by other prey, and a multitude of granules, granular spheres, and masses of protoplasm. These Amœbæ grew rapidly, and had an extraordinary power of finding food. They clung to the edges of the mud or confervoid mass in the cell, and if they accidentally roamed away, they began to move the front end first to the right and then to the left, stuck their small end downwards, and elevated the rest of the body and searched in all directions for something solid to touch. Every now and then a rush or flow of transparent diaphane would come out of the sides or large end, but never from the other; and part of the endosarc would often follow. But long sharp pseudopodia, or even long blunt ones, were never projected. As growth proceeded, several contractile vesicles appeared; and finally the form already described was assumed. Moreover, the final fate of this remarkable kind appeared to be that the quiet stage ended in one of encystment; that is to say, the outer part of the thin diaphane became more solid, the whole assuming the permanently globular form without movements. Then rupture of the side occurred after some days, and myriads of minute round masses with a spot in their midst escaped, each to develop into a tiny mobile Amœba.

It would appear that these two Amœbæ have the same kind of life cycle. First a minute globe of protoplasm with a translucent spot in the midst enlarges in diameter, and assumes an elongate form; then as growth proceeds, it becomes active, takes food at one spot, and moves in one direction. An endosarc with vacuoles and contractile vesicles becomes more and

more apparent, but still only arbitrarily divisible from the diaphane; and a nucleus is always present, although often seen with difficulty. As growth proceeds, one kind projects blunt pseudopodia very readily, and changes its shape constantly; and the other puts forth rounded flowings, but maintains its general outline. The first kind becomes quiescent, evacuates much, and even gets rid of granules, which are minute Amœbæ, and at last either bursts or encysts and bursts. The other kind has a roaming stage prior to its quiescent condition, which terminates in encysting, and subsequently in what may be called swarming of its included parts.

The commonest Amœba differs from the very lively form, and is so transparent and so slow in its ever-progressing change of shape that it may be readily passed over unnoticed when young. It occurs everywhere on the mud, vegetation, and on the glass, as well as occasionally in mid-water, where it has been wafted by the currents of some Vorticellæ or other whirling animalcula. Visible as a minute glairy spot when in its early stage, it may grow to $\frac{1}{25}$ inch in length, and then, when crammed with food, is a very fine object. Taking a large one as an example, it will be found that when on the glass (fig. 1), it looks very flat and very transparent, the endosarc hardly differing from the diaphane in its light-transmitting powers. Numerous projections of the diaphane (pseudopodia) are seen all around; some are blunt, and others are sharp, and several circular spaces readily transmitting light are to be noticed in the midst of it. After a while a languid movement occurs; a process is enlarged, another may move its free end, a new one is slowly protruded, and one of the clear spaces shuts up with a quick motion. By-and-by the creature begins to change its position, and then the invariable hand-shaped Amœban outline is assumed, that is to say, one end becomes smaller and the opposite larger; the largest pseudopodia and rounded occasional swellings are at the large end, which invariably moves first and in advance. Should any obstacle come in the way, the body flows on either side, and may spread out in a wonderful manner; but the small end has a greater density than the other, and does not give way, so that the movement takes place in a sliding manner round the object, and sooner or later the old and normal outline is seen. Many of the clear spaces in the endosarc are evidently not capable of contracting, but they are of all sizes, and sometimes a very large one may exist.

These vacuoles (fig. 1*a*) arise spontaneously or else are formed around some minute object which has got into the Amœba. They are digesting spaces. Amongst them may be seen a semilunar space (*b*), through which light passes readily, and it bounds a dark body which, although usually near the small end of the

Amœba, often travels about the endosarc. This is the nucleus, and it is made up of a less watery protoplasm than the rest of the Amœba, and has a structureless membranous coat surrounding it. Very often a clear space seems to appear and to move, but not in a manner resembling a contractile vesicle; and if the focus of the object-glass be altered and taken a little from off the ordinary level, a pseudopodium will be found sticking up from the Amœba and waving slowly in the water. It is the base of this fine projection which gives the appearance just noticed. As this Amœba moves slowly along it catches and sticks by its small end to the minute things which come in the way. The large end ever in advance moves over every obstacle around and under it, but the most tempting food never sinks in or is caught by it. The pseudopodia become very active with growth and more and more disposed to be large and rounded (lobose), but neither they nor the sudden outrushes of diaphane catch or include anything. A little watching will show that the spot where things are taken in is close to the small extremity, and that very often one or more pseudopodia are projected there, so as to encircle a diatom or a green animalcule or a piece of alga, which is slowly pressed by them against the Amœba and then sinks in. The prey becomes environed by a vacuole, or is tumbled about in the endosarc amidst the jumble of things there. It would appear that the pseudopodia, besides their locomotive use, give warning of good things being about; and if one of them should touch one of the long straggling threads of a Gromia, the whole Amœba will often change its direction of movement, gradually slip under the house of its prey, and the Gromia falls into the endosarc at the usual spot for the inception of prey. Every now and then, as this Amœba grows large, long lines appear to form on its surface (fig. 32), ridges of diaphane, which radiate more or less from the small to the large end; and, moreover, occasional collections of endosarc and food crowd the small end, and some granules and bits of digested food escape. Should one of these Amœbas, with its pseudopodia well put forth, come within the range of the current of a Vorticella, it is whisked off the glass and whirled here and there until it comes with a bounce against the disturber (fig. 30.) Now, it is a very important fact, and one which lets a great deal of light into the nature of the Amœban protoplasm, that no active or passive contraction should occur in it notwithstanding all this ill treatment. Just as when an animalcule with long cilia comes rushing against an Amœba, so, in the instance of the contact with the Vorticella, no evidence of contractility or irritability of the protoplasm is seen.

Growing day by day, especially if there is abundance of unicellular algaceous food, this fine Amœba finally has its en-

dosarc encroaching everywhere on the diaphane, so that a granular globular form surrounded by a thin film of diaphane is produced. Now this diaphane film plays all sorts of antics before settling down into a dense film of investment; it even pokes out long rays (figs. 34, 37), and tries to simulate the Sun Animalcule. But at last the delicate film becomes motionless and acts as a membrane around the globular mass, in which some movement may still be seen, and in which the nucleus is occasionally visible. The duration of this stage evidently depends on season, warmth, and the presence of much or little water; and it would appear that its commencement has a great relation to the prospective scarcity of food and water. As ponds commence drying up and algæ finish their spore-making, Amœba begins to think about the future, and soon encysts itself. This may be artificially brought about in May, June, and July in a little aquarium; and if the water is allowed to get low no active Amœbæ will be found, but lots of globes (fig. 27).

Although I had watched Amœbæ for a considerable time at intervals, and had had the same individuals living in a cell for days, a long time elapsed before I saw one cast off a pseudopodium which assumed an independent existence. It was one of the kind just noticed, and all the food that was within the endosarc was a great Pinnularia semi-digested. The Amœba was large, $\frac{1}{50}$th inch, and had evidently reached a critical point in its existence, for it was crowded with small granule-globules, and the only diaphane which was at all persistent was at the large end. Elsewhere the very fluid-looking endosarc appeared to have merged into diaphane. The Amœba rounded off its smaller end and then began to move as usual, broad end first, protruding diaphane first on one side and then on the other in lobose swellings. Suddenly it protruded, from the junction of the smaller end with the rest, a blunt pseudopodium which increased in size until it was two-thirds of the length of the whole, and then endosarc streamed into it (fig. 31). My attention was drawn to this rather unusual occurrence, and especially as a distinct round body got in as well. This was a nucleus; but whether the only one, or whether the original remained behind in the larger body hidden, could not be determined. All of a sudden the pseudopodium separated close to the body (fig. 35), which then altered its shape generally, and moved off. There was an escape of one granule-sphere only, and motion ceased in the cast-off member, which looked dead and flat. Presently the original free end of the piece began to move and project diaphane on either side, and a slight streaming of the granules and nucleus occurred in that direction. Then the ruptured end contracted, and two processes started from it, resolving themselves in a few seconds into a rounded small end (figs. 33,

33*a*). Here was a new Amœba, but as yet there was neither contractile vesicle nor vacuoles. It began to move actively, and got amongst some algæ, and was lost to view. It was a most startling proceeding, and would appear to be of rare occurrence. Absolute splitting in half, or what may be properly called fissiparity, I have not seen in Amœbæ.

As some of these Amœbæ gradually became quiescent it was possible to examine the nucleus, and by transferring them to a glass slide and employing a $\frac{1}{16}$th immersion object-glass, the structure of this remarkable piece of differentiated protoplasm could be pretty well made out. The nucleus (figs. 1*b*, 6, 36, 44) is usually darkish, not very transparent, and its investing structureless dense film is partly surrounded by a clear space; but, as age comes on, this space is often lost, and the little body is enclosed in a mass of granular protoplasm belonging to the endosarc. Then a small globule or nucleolus becomes readily visible within the nucleus (fig. 39). But it nevertheless sometimes happens that the clear space increases in size and completely surrounds the nucleus. In both instances it may be observed that the nucleus subdivides within its investing film, so that it appears to be a mass of closely-packed nuclei or small globes. Now these tiny globes greatly resemble some of the granule spheres of the endosarc, and as these are the rudiments of young Amœbæ it is quite possible that those of the nucleus will turn to independent individuals when the whole bursts.

It is incredible what a number of these tiny dots of granules escape from a good-sized Amœba when it bursts; hundreds of thousands move off from the mass and indulge in the fidgets of the Brownian movement until they increase in size and throw out a process and become masters of their movements to a certain extent (fig. 13).

One more Amœba must be noticed (figs. 38, 40); it is common up to a certain time of the year, becoming encysted before the hot weather sets in; or else it hides up amongst the mass of mud and tangled confervæ on the floor of the pond. It is only to be found in the waters which are tinted more or less with an iron rust colour; and as a rule it is so greedy and so constantly devouring its minute prey that it does not readily come out into the clear water of the cell. This Amœba may, therefore, readily escape notice. The first seen by me was half hidden under grains of dirt and a jumble of Desmidia and Pinnulariæ, and as the part visible resembled the ordinary Amœba just described, no attention was paid to it. But after a while a great flow of clear diaphane occurred from the mass, which was followed by a rush of granules into the rounded projection, the whole being in a very tumultuous state. Then a great cylindrical Amœba streamed forth, one end first as usual, and at the opposite end of the body

there was a narrowing, then a little neck and a round globular head covered with very minute, short, hair-like processes. This was something quite new, and it was very exciting to observe the curious movement of the body and the comparative steadiness of the curious neck and head. The diaphane was scanty near the head, but abundant at the opposite or forward-moving end; and the endosarc, dense, granular, and nearly opaque at the head and neck, became more diffluent elsewhere. The endosarc was in wonderfully active movement, pouring down the axis of the sausage-shaped thing, streaming out into the diaphane as it altered its shape, and approaching the very edge with active motion; then it turned backwards on all sides, so that a counter current occurred near the whole surface, the granules moving then towards the head. Then they entered the axis again, and could be followed about here and there until they got into the stream and rejected their former path.

No pseudopodia of any size came forth; but there was a lobular projection, first on one side of the forward-moving end and then on the other (fig. 38), the one being overwhelmed by the other as general movement progressed. Two or three small angular pseudopodia came out, and remained not far from the neck. Under a one-eighth inch object-glass the motion of the contents of the endosarc was very curious, and a good deal of it was independent of the contraction and dilatation of the diaphane and endosarcal protoplasm. The movements of the protoplasm produced great currents, but there was something going on like that movement which can be usually seen in the ends of the crescent-shaped green Closterium. As the Amœba moved along nothing got into it; and an animalcule came at full speed against its sides, but made no impression. After a while a change of shape occurred, the cylindrical form gradually merged into the hand-shaped (fig. 40), the head and neck still retaining their size and position at the end remote from forward movement. As the body flattened out, the nucleus became visible, and the contractile vesicle more distinct close to the junction of the head and neck. The minute long pimples, like stumpy hairs on the globular head, move, but do not increase in size except in length. I did not see any food taken in, and indeed the creature was pretty full; but after it had been in open water for an hour or so, it began to be uneasy and to move, wide-end in advance, first on one side and then on the other, as if seeking for something to eat or move amongst, and finally it disappeared under some conferva.

The next of this kind I saw feeding. The creature came out of a mass of vegetation with a bundle of minute things sticking to its head, and it dragged its load about until finally something stopped the way and the head made its appearance. There was

then a movement of pulling before the evidently very sticky short hair-like processes would condescend to give way (fig. 40). They did at last, having been more or less elongated, and there was a decided and active expression of relief in the jerk-like onward movement of the Amœba. The creature had several of the short, wedge-shaped pseudopodia close to the neck, and as it turned to reconsider its bundle in a very unautomatic manner, those of one side came in contact with some broken-down granules and conferva cells. The pseudopodia closed on the granular mass and brought it to the part where the neck of the head joined the main body, and the prey sank into the endosarc. I have repeatedly seen these Amœbæ take in food, and it has always been at this particular spot.

Growing to a large size for Amœbæ, these tufted ones are by far the most interesting to observe, and there is no doubt that they have the usual life-cycle of the group. The last I watched disappointed me sadly. It had grown corpulent and sluggish, and I trusted that it was about to encyst, but suddenly it assumed the spherical shape, the head and neck were lost in the general rotundity of the surface, and then the mass burst at one spot, and endless granule-spheres came out. The young of this Amœba have the head-tuft at a very early age, and, like the old, never move head first. Like the other Amœbæ they now and then play antics, change their shape, cling on by one long leg and cast out others, then pull all in, and sail off in the shape of a sausage or a hand with the fingers extended.

The parts of an Amœba are its diaphane and endosarc; the nucleus, the contractile vesicles and the vacuoles are invariable structures; and the granule-spheres and some odd crystalline-looking grains are seen in varying quantities. It is evident that there is no positive distinction to be made between the diaphane and the endosarc, and one can become the other; but the nucleus is a special structure, and has its investing film and a nucleolus.

When the smallest Amœba visible with the highest powers of the microscope is watched for a minute or two, a tiny spot, usually not far from its centre, will be seen to enlarge, remain, and then suddenly disappear. If the object be still observed, the spot will be found to re-appear as a point and then to enlarge and pursue the same course. Larger Amœbæ and the very largest also present one or more of these dilating and shutting-up spots in their midst; and certainly the more they are watched, the more does their extraordinary character impress itself upon the observer (fig. 1*c*). The spot is in the denser substance of the Amœba, but one may often be seen so close to the edge (fig. 16) that it must be in the diaphane. It is spherical in shape, and therefore circular in outline, but the pressure of the moving

granules in their rushes and streamings may alter the shape for a while; there is no limiting or enclosing membrane, but in large Amœbæ, where this contracting bladder or vesicle is very visible indeed, something like a rough edge appears within. Evidently the light traverses the spot more readily than it does the surrounding protoplasm, and this is due to its being filled with a more highly refracting medium—water. The water coming from somewhere collects as the protoplasm expands actively from a point-like space; and then when it contracts more actively in a more or less observable rhythm, the water is expelled and goes somewhere. This pulsation, or what the doctors would call systole and diastole, occurring in a structureless material, is as incomprehensible as the outside change of shape, and the protrusion and retraction of the pseudopodia. The active expansion would suck in water from the surrounding mass, and it appears to do so generally, and not through any canals or conduits; and the sudden and very vivacious contraction must, one would think, rupture the surrounding soft material unless there were permanent minute porous tubes in it. On watching with the highest powers no displacement of the surrounding granules can be noticed after one of these active closings of the contractile vesicle; but they sometimes precede a new movement in the general mass, such as the commencement of a streaming in a new direction, or the emission of a transparent lobose or sharp pseudopodium. In some instances the vesicle is moved along with the rest of the endosarc, and contracts and dilates in the midst, so that it is impossible that there can be any permanent outlet between it and the surrounding water. But when the vesicle is in its very common place, close to the food-entering end, there is sometimes an appearance as if there was a direct discharge through the diaphane into the surrounding water. But I must confess that no motion occurs amongst the minutest particles which may surround the end of the Amœba synchronously with the active contraction of the vesicle. Corresponding vesicles occur in the Sun Animalcule which abounds in the water containing the Amœbæ, and these occur on the very edge of the protoplasmic mass, bursting with such force as to shake the creature. The exit of their contents into the surrounding medium is visible enough, but this is not observed in Amœbæ.

Sometimes, when there are two contractile vesicles, they unite, and one large spot is produced which either assumes the spherical shape or remains irregular in outline until it contracts and disappears. Under all conditions, and whether the Amœba is flourishing or dying from inanition and pressure, the contractile vesicle enlarges to its full size slowly in comparison with the sudden contraction, but the frequency of the pulsation,

if it may be so called, appears to relate to the health of the creature. The vesicle may be seen stationary for a long time when the empty endosarc, with hardly a trace of food in it, is pale, and not very distinguishable from the diaphane, but when the whole is well nourished the vesicle appears and disappears with remarkable regularity.

The function of this extraordinary arrangement is probably in relation to respiration and circulation. Either the contents which are drained or sucked out of the surrounding endosarc are water, or water and very liquid stuff which will eventually become endosarc or diaphane; the contraction redistributes the water, and pumps the results of the simple digestion, diffused, as it has been before, again into the mass. But it has been observed a few lines back that some change in the direction of the streaming of the endosarc, or the protrusion of a pseudopodium, frequently occurs immediately after the contraction of a vesicle, so that it is quite possible that its function refers to the diffusion of a nutritive liquid as well as of simple water. All animalcules, and a great many small moving things which are classified as water plants, have these vesicles, and whilst in some they burst through a tube or directly into the surrounding water, those of others, in some rare instances, force their contents through radiating canals into the body of the creature. It would appear that a definite mass of endosarc always maintains itself around the vesicle; and therefore it follows that one particular mass of the protoplasm of the creature is endowed with a permanent function, and a power of dilating and contracting with rhythm.

On the other hand, vesicles appear where formerly they were not, so that it must be admitted that this interesting power of radial expansion and concentric contraction is common to the tissue of the Amœba generally, and that it is a specialized gift analogous to the ordinary protrusion of the diaphane, and its retraction and curving pointin one direction and then in another.

A large Amœba with a very delicate endosarc had been feeding on broken-down conferva, spores, and green cells, when a tolerably large diatom (fig. 17), a Pinnularia, came in contact with its small end. The scanty diaphane then immediately increased in quantity and flowed over the intruder, which sank, as it were, gradually into the endosarc, and remained in one part of it. After a few minutes had elapsed, a clear space formed in the Amœba around the prey, which immediately began to move in it forwards and backwards after its usual fashion. The space was evidently filled with water, and therein moved the captured diatom, apparently in no great discomfort. After long watching it became apparent that the size of the space, or *vacuole*, as it is termed, increased, and that the diatom became

stationary and ragged-looking, and in the course of more than a day it split and separated into two halves. After this the vacuole disappeared, and the relics of the meal were jumbled up in the group of granules and other digested bits which streamed about in the endosarc.

Anyone can see what has been just described, and the whole life-history of Amœba can be followed with ease with ordinary appliances. If a young microscopist has satisfied himself that all that has been stated is true, he will stand in the same position with regard to myself that I do to a great many English and foreign observers. All that has been noticed in these studies will be found somewhere or other, and I found it most interesting and instructive to study the work of Dr. Wallich, in the "Annals and Magazine of Natural History," for 1863. There the hairy Amœba is admirably described, and christened *Amœba villosa*, and all its oddities are explained; there the reciprocal nature of the endosarc and diaphane, the nature of the nucleus and the method of its sub-division, and indeed the exact morphology of the Amœbæ is given to perfection. Carter, Carpenter, and Williamson have discovered and described much, and many species have been made and described by them and by learned Germans. One thing has struck me, and that is that there are two species of Amœba only, and not a score. There is *Amœba villosa*, which is really a "crowned head" (figs. 38, 40). Then there is the other, which according to locality, time, season, food, and the eyes of the observer, changes its general shape and receives many names, but it is the common form at Hampstead, and is called *Amœba princeps*. It ought to be *Amœba communis*, as it is plebeian to the regal *Villosa* (figs. 1, 2, 3, 7, 9, 10, 13, 21, 22, 30, 31, 40, 41).

DESCRIPTION OF PLATES V. AND VI.

The arrows point in the direction of movement during regular progression.

FIG. 1. A large Amœba with contractile vesicle, nucleus and much food.
FIGS. 2 and 7. A large and very active Amœba (a peculiar stage).
FIG. 3. Amœba, comfortable, and full of food and large vacuoles.
„ 4. An Amœba with endosarc reaching edges of diaphane.
„ 5. The same, with general shape changed. Nucleus shown.
„ 6. Nucleus, nucleolus, and granule-spheres.
„ 8. Commencing quiescence before encystment. Sarcoblasts of Wallich.
„ 9. Amœba with endosarc in the midst (a peculiar stage).
„ 10. The same, assuming the normal shape.

FIG. 11. The edge magnified (one-sixteenth immersion), showing ragged diaphane, and sarcoblasts, or granule spheres.
„ 12. Amœba imitating Actinophrys before encystment.
„ 13. Development of Amœba from a granule-sphere.
FIGS. 14, 18, and 41. Digested food and granule-spheres escaping.
FIG. 15. Endosarc and food close to the margin.
„ 16. Contractile vesicle expanded and close to the edge.
„ 17. Vacuole containing a moving Pinnularia.
„ 19. Contact previous to union of two Amœbæ.
„ 20. Amœba with large contractile vesicle, small nucleus, and several pseudopodia.
FIGS. 21, 22, 23, 24, and 25. Amœbæ under different circumstances.
FIG. 26. Amœba bursting and giving forth sarcoblasts or granule-spheres.
FIGS. 27 and 29. Encysted Amœbæ.
FIG. 28. A small active Amœba, formerly inactive.
„ 30. Amœba floating free.
„ 31. Amœba with a nucleus in a pseudopodium.
„ 32. A large Amœba with radiating ridges of diaphane.
FIGS. 33 and 33*a*. The growth of the head end of the new Amœba.
FIGS. 34 and 37. Imitating Actinophrys before encystment.
FIG. 35. Pseudopodium cast off.
„ 36. Nuclei.
„ 38. Amœba villosa, *Wallich.*
„ 39 Nucleus.
„ 40. Amœba villosa.
„ 42. Margin of "head," showing hairy projections after contact.
„ 43. Amœba (the common one) uncomfortable.
„ 44. A nucleus.
„ 45. Moving off.

MARS IN THE AUTUMN OF 1877.

BY RICHARD A. PROCTOR, F.R.A.S.

[PLATE VII.]

IN the years 1867 and 1869 I discussed in these pages the relations presented by the planet Mars during the oppositions of those years, when the planet was traversing the aphelion portion of his orbit. Since that time several observations of interest have been made upon Mars. Moreover, Dr. Terby of Louvain has brought together many observations, made since the year 1630, but which had before been scattered in the Proceedings of learned Societies, in the private notes of observers, and elsewhere in such sort as not to be directly available to science. I may remark, indeed, in passing, that we find illustrated in this case what I cannot but regard as a serious disadvantage of the action of learned Societies. Enabling observers, as these Societies do, to publish the results of observation, the Societies do good work; for many observers could not otherwise perhaps afford the expense of making their work known as it proceeds. But in several cases it has happened that this piecemeal issue of important labours has prevented the publication of the entire series, revised and corrected by the observer himself. For example, we no doubt owe a debt of gratitude to the Royal Society for publishing the successive papers on the stars drawn up by Sir W. Herschel; yet no one can doubt that if it had so happened that Sir W. Herschel had been compelled to wait until his labours were concluded, or at least until each successive stage of his progress had been completed, and had then presented his work to the world, its value would have been enhanced tenfold, though probably he would have been put to no small expense, which the Royal Society saved him. In the case of observations made on Mars, we have not the results of any single observer's work presented in detail even in the Proceedings of Scientific Societies, only a few selections here and there, such as the observer thought most likely to be published for him; or, in some cases, a few only from among these. Thus,

we have not any complete account of the observations made by Schröter, W. Herschel, De la Rue, Dawes, and a host of other observers, but only a few fragments here and there. I venture to say that the work done by Dawes alone upon Mars, if it had been brought together by himself and published as a book, would have done more to throw light on the planet's condition than such scattered selections from the labours of a dozen of the best observers (including himself) as are alone available to us under the present system.

It will be well, before proceeding to consider the features to which telescopists should direct their attention during the approaching opposition of Mars, to note the order in which favourable and unfavourable oppositions of Mars succeed each other. The coming opposition, as most of my readers doubtless know, is one of the most favourable of the present century. The planet will not be quite so near to perihelion, at opposition, as he was in 1845 (when, by the way, many observations of interest were made); but he will be more favourably situated for observation in our northern hemisphere, because of his less southerly declination. In 1830 he was more favourably placed in this respect (being nearly on the equator at opposition), but further from perihelion. In 1892 he will be at once further from perihelion and less favourably placed. These oppositions (1830, 1845, 1877, and 1892) are the nearest to perihelion during the present century; after them come, in order of distance, 1862, 1860, 1847, 1879, 1875, 1864, 1890, and 1881.

It is easy to ascertain the circumstances which determine the recurrence of oppositions in favourable and unfavourable positions.

The sidereal period of the earth being 365·2524 days and that of Mars 686·9797 days, in order to determine the varying position of oppositions we must in the first place consider the improper fraction $\frac{6,869,797}{3,652,524}$, and, presenting it as a continued fraction, obtain from it a series of fractions approaching it more and more nearly in value. (The remainders obtained in this process all represent the number of days by which various multiples of the sidereal year and the sidereal period of Mars differ from each other.) We obtain:

$$\frac{6,869,797}{3,652,524} =$$

$$1 + \frac{1}{1+}\,\frac{1}{7+}\,\frac{1}{2+}\,\frac{1}{1+}\,\frac{1}{1+}\,\frac{1}{3+}\,\frac{1}{1+}\,\frac{1}{1+}\,\frac{1}{7+}\,\frac{1}{1+}\,\frac{1}{6+}\,\frac{1}{2+}\,\frac{1}{5+}\,\frac{1}{3+}\,\frac{1}{1+}\,\frac{1}{3}$$

(I commend the prevalence of 1's, 3's, 7's, and 2's in this result, and the absence of 4, 8, and 9, to the special attention of all who find strange significance in the excess of 3's and the

paucity of 7's in the number representing the ratio of a circle's circumference to its diameter.) The corresponding fractions are $\frac{1}{1}$, $\frac{2}{1}$, $\frac{15}{8}$, $\frac{32}{17}$, $\frac{47}{25}$, $\frac{79}{42}$, $\frac{284}{151}$, $\frac{363}{193}$, $\frac{647}{344}$, $\frac{4892}{2601}$, $\frac{5539}{2945}$, &c.; and the corresponding relations, which chiefly concern us, are these:

1 sid. per. of Mars − 1 sid. year	=	321·7333	days
2 sid. years − 1 sid. per. of Mars	=	43·5331	„
8 sid. per. of Mars − 15 sid. years	=	16·9916	„
32 sid. years − 17 sid. per. of Mars	=	9·5499	„
25 sid. per. of Mars − 47 sid. years	=	7·4417	„
79 sid. years − 42 sid. per. of Mars	=	2·1082	„
151 sid. per. of Mars − 284 sid. years	=	1·1171	„
363 sid. years − 193 sid. per. of Mars	=	0·9911	„
344 sid. per. of Mars − 647 sid. years	=	0·1260	„
4892 sid. years − 2601 sid. per. of Mars	=	0·1091	„
2945 sid. per. of Mars − 5539 sid. years	=	0·0169	„

So that between the time of the opposition of Mars which occurred in the year 3662 B.C. until our earth came to the same part of her orbit (not the same part of the year of seasons, but of the sidereal year) Mars will have made 2945 sidereal circuits *plus* his motion in 0·0169 days, or in 24 min. 20·16 seconds. This is the nearest periodic approach (I refer to the near equality of 2945 periods of Mars and 5539 years) during what is commonly regarded as historical time; since the next fraction after $\frac{5539}{2945}$, derived from the continual fraction above given, has for its numerator $5539 \times 6 + 4892$ or 38,126, which is the number of sidereal years of the corresponding relation between the periods of the earth and Mars: 20,271 sidereal periods of Mars fall short of this long interval by ·0077 days, or 11 min. 5·28 sec. Beyond this we need not care to proceed.

The use of the relations above tabulated will be very obvious. It shows first the number of years separating similar oppositions of Mars, the closeness of the similarity depending on the smallness of the number of days representing the difference between so many years and the corresponding number of periods of Mars. Thus we see that in fifteen years from any given opposition, Mars is removed seventeen days' journey from the prolongation of the line extending from the sun to the earth. That line, or the earth's radius vector produced, has passed Mars recently therefore, and we have to carry it back at the earth's daily rate of angular motion round the sun, carrying Mars back by his less rate of motion, until the earth's radius vector passes through Mars, to get the place of opposition, which of necessity precedes the place of opposition fifteen years before. Since the earth's mean daily rate is 3548″·193, and Mars's 1886″·518, the difference, 1661″·675, is the earth's daily gain; and we have only to find out how often this is contained in 17 (or more exactly

16·9916) times the daily motion of Mars, 1886″·518, to find by how many days on the average the date of the later opposition precedes the date of the earlier. We find the average difference of date to be about 18⅓ days. But owing to the considerable eccentricity of the orbit of Mars and the consequent variation of his daily motion, the difference of date largely exceeds this value for oppositions occurring near perihelion, and largely falls short of it for oppositions occurring near aphelion. For instance, the opposition of 1862 occurred on or about October 5, while that of the present year—fifteen years later—occurs on September 5, thirty days earlier. On the other hand, the opposition of 1869 took place on February 13, while that of 1884 will occur on or about January 31, about thirteen days earlier.

In a similar way the closer approach brought about in thirty-two years, and the still closer approach brought about in forty-seven years, can be dealt with.

The approach brought about in seventy-nine sidereal years is so much nearer that it merits closer attention. We have the general relation that seventy-nine sidereal years exceed forty-two sidereal periods of Mars by 2·1082 days (or 2·1 days, nearly enough for our purpose). And we have for the average case, of course, the same daily motions as before; whence the average number of days by which an opposition in any given year falls later than one occurring seventy-nine years before is equal to 1886″·518 × 2·1 divided by 1661·675 or about 2·4 days. But when Mars is near perihelion his daily rate of motion is about 2286″, while the earth in the corresponding part of her orbit has a daily rate of about 3470″; consequently, the daily gain of the earth is about 1184″ only, with which gain a difference of 2·1 times 2286″ has to be made up. Hence we have for the interval in days between two oppositions occurring near perihelion and separated by seventy-nine years 2·1 times 2286 divided by 1184, or 4·14 days. On the other hand, when Mars is near aphelion his daily rate of motion is about 1576″, while the earth in the corresponding part of her orbit has a daily rate of about 3636″, so that the earth's daily gain is 2060″, with which gain a difference of 2·1 times 1576″ has to be made up. Hence we have for the interval in days between two oppositions occurring near aphelion and separated by seventy-nine years, 2·1 times 1576 divided by 2060 or 1·66 days. (The date of the later opposition follows the date of the earlier.)

The approaching opposition is important in two chief respects. First, it affords a favourable opportunity for determining the sun's distance: and secondly, it will be possible to study under very favourable conditions the southern hemisphere of Mars.

On the first point it is not necessary to say much here. I have already entered somewhat fully into the merits of this par-

ticular method of determining the sun's distance in Chapter I. of my treatise on the Sun. I believe it will be found that the observations to be made next September by this method will afford measures of the sun's distance comparing favourably with those obtainable by any other methods, including the observation of Venus in transit. It is unfortunate that official astronomers in this country have not endeavoured to obtain the sanction of Government for any expeditions by which advantage could be taken of the near approach of Mars. But it must be remembered that, being themselves in the receipt of money from Government, they naturally feel some delicacy in advocating the outlay of Government money on the observations of special phenomena outside the routine of work in the public observatories. It is understood, too, that apart from any question of delicacy, Government observers have lately had good reason for avoiding any suggestions in favour of expenditure on scientific expeditions, very plain hints having been given them that it does not fall within the duties of their office to make such suggestions. Be this as it may, it is certain that the only expedition for observing the approaching opposition of Mars is one undertaken by Mr. Gill, who managed very successfully the heliometric observations of the transit of Venus at the Mauritius (Lord Lindsay's transit expedition). For this expedition a sum of 500*l.* has been provided by the Astronomical Society, and the fine heliometer used in 1874 has been lent by Lord Lindsay.

The observation of the features of the surface of Mars, though not a task of equal difficulty, is one of nearly equal scientific importance. Whether the Sun is a few hundred million miles nearer to us or farther from us than had been before supposed, is in reality a matter of very little moment. The exact determination of the Sun's distance, if it could be effected, would not have the least practical value, and in this sense would not be one whit better than the determination of the true shape and position of the lands and seas of Mars. There is a meaning, indeed, in every change in our estimate of the Sun's distance, which is full of interest for the student of nature; but surveying astronomy, so to describe the work for which Government observatories are established, could get on quite as well if the Sun's distance were erroneously estimated by many millions of miles, as if we knew the distance to a hair's breadth. Certainly the determination of the physical features of a planet is not devoid of interest for the student of science; it enables us to judge of the planet's actual condition, to compare the planet with our earth, to draw inferences respecting the influence of a planet's size, mass, and position on the progress of those various changes which constitute the life-history of the planet. Indeed, I do not hesitate to say that if we could obtain exact knowledge

respecting the physical condition of the Moon, Mars, and Jupiter, the information would largely surpass in real interest the most correct determination of the Sun's distance. If any proof of this were needed, it would be found, I conceive, in the fact that every piece of information obtained respecting the physical condition of the planets is at once recognized as full of significance, whereas when a change has been made in our estimate of the Sun's distance, corresponding changes are made in the numerical relations indicated in our text-books, and that is all. No suggestions are made, and indeed none seem needed, to the effect that we must modify views formerly entertained respecting either the Sun or the members of his family. The determination of the Sun's distance, in fact, is a problem of surveying and statistical astronomy, not of that living astronomy, which alone has any interest for us as reasoning inhabitants of one of the worlds which fill God's universe.

The aspect which will be presented by Mars as seen in the telescope will not differ greatly at any time during the approaching opposition from that indicated in the six illustrative projections (Pl. VII.). These represent six stages of Martian rotation, separated by 60°, or by 4 hours of Martian time. On Sept. 5, Mars comes into opposition at midnight. At this hour the Martian meridian crossing the centre of the disc of Mars will be very nearly in 26° east Martian longitude, or the meridian passing some 15° east of Dawes' Forked Bay in the accompanying chart (p. 245). The view nearest to this in the series of six is No. 2, in which the central meridian is in 30° Martian longitude east. The rotation of Mars occurring in the direction shown by the arrow, and one degree of rotation being completed in about 4m. 6¼s., it follows that the aspect shown in No. 2 will be presented at about 16½ minutes before midnight Sept. 5. The observer will have no difficulty in determining when the other views may be looked for. On any the same night, the interval between one view and the next amounts to about 4h. 6m. 14s. (the rotation period of Mars being 24h. 37m. 22·7s.); and neglecting the angular motion of Mars about the earth, which in such a case we may do for short intervals of time, any view changes nearly into the *preceding* for the *same* hour of the night in the course of six nights. For, in each terrestrial day the planet completes one rotation, less the amount of rotation corresponding to 37m. 22·7s., and six times this daily loss of rotation gives the rotation corresponding to about 3h. 44m. 16s., or only 22m. short of the amount corresponding to one-sixth of a Martian day. In seven days, the loss corresponds to 4h. 21m. 39s., or only about 15⅓m. more than the amount corresponding to one-sixth of a Martian day. Thus, neglecting his angular motion round the earth, Mars presents

the aspect shown in No. 1, six days less 22 min., or seven days *plus* 15½ min. *after* he had presented the aspect shown in No. 2.

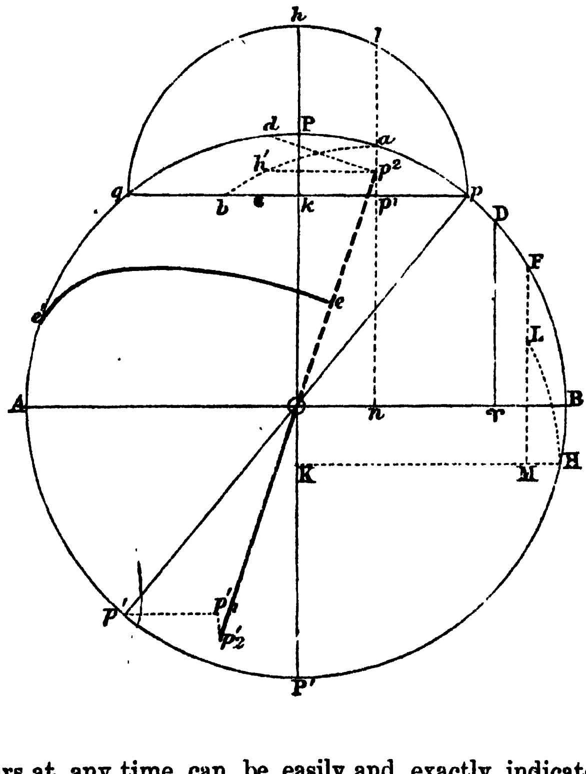
It may, however, be convenient to the observer to introduce the correction for Mars's angular motion round the earth, which, indeed, though small for the motion of Mars during six or seven days (even) when he is in opposition, necessarily becomes appreciable in the course of several weeks, during which the planet is favourably placed for observation before and after opposition. The correction can readily be made as follows. From the "Nautical Almanac" mark in the position of Mars at intervals of ten days (say) in any atlas showing longitude and latitude. (In my "School Atlas" the longitude and latitude lines are indicated by their points of intersection to every 30°; but it will be found easy to fill in, on a tracing taken from the proper map, the intermediate longitude and latitude lines to every 5° or 10°). Thus the geocentric motion of the planet in longitude is indicated. Direct motion in geocentric longitude delays *pro tanto* the coming of a Martian meridian to the centre of the disc of Mars, while retrograde motion in geocentric longitude hastens *pro tanto* the arrival of a Martian meridian at the centre. For instance, suppose that on a given day soon after opposition Mars has retrograded a° in longitude from his opposition place on the chart and that the epoch t is calculated for a given view of the six formulas numbered 1, 2, &c., without taking into account the change of Mars's position relatively to the earth. Then that view will be presented at the time $t-(4\text{ m. }6\tfrac{1}{4}\text{ s.})a$.

The above data will be sufficient for determining the aspect of the planet at any time during the approaching opposition. Account will, of course, have to be taken of the gibbosity of Mars, as affecting the apparent position of his central meridian at any time; but the "Nautical Almanac" supplies the necessary information for this purpose.

The points to which I would direct the special attention of observers are three,—first, the position of the south polar snow-cap; secondly, the rotation-period of the planet; and thirdly, the determination of the configuration of various lands and seas presently to be mentioned.

If on every good observing night the angle of position of the centre of the snow-cap with reference to the centre of the disc could be determined in the same manner as in the case of a double star—the centre of the snow-cap corresponding to the companion and the centre of the disc to the primary—the observations could not fail to be of value, as showing whether the snow-cap occupies the true pole, or if not, how far from the true pole its centre lies, and also showing where the true south

pole of the planet lies. I do not here enter into the consideration of the method of calculating from the observed angle of position the true position of the axis, simply because the reader for whom the explanation would have any meaning will be able quite readily to obtain the required formulæ for himself. They are presented in an article of mine upon the opposition of Mars in 1873 in volume xxxiii. of the "Monthly Notices" of the Astronomical Society. But as there are some who find formulæ perplexing, especially when the manner in which such formulæ have been obtained is not indicated, I deem it desirable to indicate a construction by which the proper bearing and position



of Mars at any time can be easily and exactly indicated. It can easily be shown that this construction corresponds with the spherical formulæ given for such cases in the above-mentioned volume of the "Monthly Notices," and also in the explanation of Tables VII. and VIII. of my work entitled "Saturn and its System."

Describe a circle APB, and let POP′, AOB be diameters at right angles to each other. From P measure on PB an arc PD

47° 56′ (the angle N of the formulas), and draw DΥ square to AB. From DA measure off the arc DAP′BF equal to the right ascension of Mars at the time considered. (I have taken the actual right ascension at the time of opposition on September 5, viz. 347° 19′; otherwise, for the general illustration of the method, I should have selected a more convenient arc.) From B measure off an arc on BPAP′ equal to the northerly declination of the planet: —the declination being southerly on Sept. 5—the extremity of this arc will fall on BP′ as at H, where BH is an arc of 12° 9½′. Draw the ordinates FM, HM intersecting in M, corresponding to the place of Mars on the star-sphere, where POP′ is the polar axis and AOB the projection of the celestial equator, Υ lying on the *concavity* of the sphere thus projected. Now take arc $\text{P}p = 39° 42'$, the inclination of the polar axis of Mars to the earth's polar axis (No. 1 of the formulas), and draw the diameter pop'. Then, if the point M be supposed brought to the centre O by two rotations, one round POP′, the other round AB, the position taken up by pp' will be the true projection of the polar axis of Mars at the time considered. The construction for this purpose is indicated by the dotted lines in the figure. (The full lines indicate constructions common to all cases; the broken lines indicate constructions for finding M; the heavy lines indicate final result, the broken heavy line being that part of the polar axis of Mars which lies between his centre and his unseen pole). Draw HK square to OP′, with centre K describe arc HL, meeting FM; draw pk square to OP, describe quadrant plh about k, take arc $hl = \text{HL}$ (*i.e.* angle $hkl =$ angle HKL); and draw lp_1 square to pk. Then p_1 is the position of p after first rotation. Next, drawing ap_1n square to OB, let p_1b square to an meet arc $ah'b$ about n as centre in b; take arc $bh' = \text{BH}$; then $h'p_2$ square to an gives the place of p after second rotation. Thus $p_2op'_2$ is the position of the axis of Mars. It is readily seen that p_2 corresponds to the unseen pole, p'_2 to the visible pole. We must now take Oe on Op_2 equal to OK, then e is the place where the equator crosses the central meridian. The rest of the construction is the ordinary projection of a sphere. Half the equator is shown. It is a good plan, by the way, to complete the construction for one-half only on tracing paper, and to prick off the two halves in the final drawing from the same tracing, first from one side, then from the other. This secures symmetry with respect to the polar axis.

The construction above given occupies only a few minutes in practice, and gives results quite accurate enough for the correction of the position of Mars's polar axis. In fact it would be well indeed if the telescopic observers could obtain results even nearly as accurate as such constructions afford.

The determination of the rotation period, or rather, observation for correcting the rotation period, needs no special explanation. We have already seen how the time when the various features of the planet's surface will come to the central meridian can be determined beforehand. It is only necessary to note the actual time when they do come to the central meridian, to ascertain whether any correction is required. But in point of fact, observations made on the planet's rotation now, will only have any real value some century or two hence. The rotation period has been already calculated to within the tenth part of a second, for though Kaiser's result differs from mine by about that amount, I have shown that there are clerical errors in his calculation, (such, for example, as his taking the years 1700 and 1800 as leap-years,) and that when these are corrected the same rotation period within a 50th part of a second results from his researches as from my own, $24^h. 37^m. 22{\cdot}7^s$.

It remains only that I should consider what special observations of the features of Mars are now likely to be of service.

In the first place, I think the time has come for a more careful study of the varieties of light and shade and of colour in this interesting planet. It should be noticed that the apparent discrepancies between many excellent drawings are probably in the main due to this cause. I have studied hundreds of views of the planets, and at first I used to be greatly perplexed by finding that two skilful observers seem to see two different planets with their telescopes. The drawings constructed by one observer agree most satisfactorily *inter se*, and so do those obtained by the other; but when one set is compared with the other the most startling discrepancies are noted. I am disposed now to attribute this chiefly to the fact that slight varieties of shade have not been sufficiently noted, or, if so, have not been adequately indicated. In the main, observers are apt to divide the surface of Mars into two tints, one light, the other dark, and one observer will set a portion which is faintly shaded in the dark part of his picture, while the other not recognising the difference of shading, perhaps, or else considering it unimportant, sets that portion in the light part. As the colouring of Mars is in reality exceedingly delicate, especially in certain portions of the planet, and as, moreover, different eyes differ greatly in their estimate of colour, the drawings are not corrected on this account, as otherwise we should expect. The ordinary text-book notion that the surface of Mars is divided into a ruddy portion, a green portion, and the white polar snow-caps—with perhaps occasional white cloud-markings—is altogether remote from the truth. Only a very small portion of the land has a ruddy tint which can be regarded as well defined,

and though the greenish line of the seas perhaps extends a little more widely (at least for most eyes) it is wanting over large tracts usually regarded as marine in character.

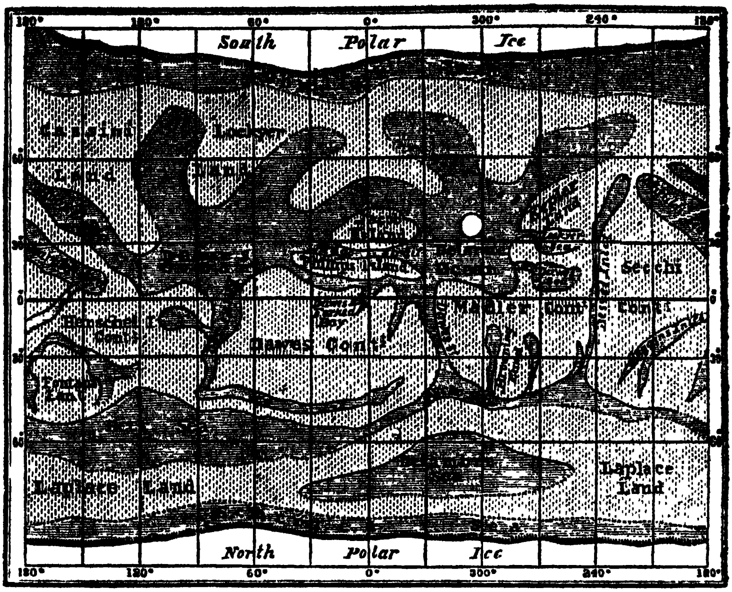


CHART OF MARS ON MERCATOR'S PROJECTION.

As a general rule it may be considered that a dark marking once fairly seen is to be regarded as indicating a sea-region, whether commonly seen or not. We cannot but suppose that on Mars as on our own earth, there are sea-regions where clouds are very prevalent, and where, therefore, we are seldom likely to catch the dark hues of the sea. Our observations are after all only made under favourable conditions at long intervals; and those of the northern regions of Mars have been as yet very imperfect, because when Mars turns his north polar regions earthwards, he is near the aphelion of his orbit, or, in other words, the summer of Mars' northern hemisphere, like the summer of our own northern hemisphere, occurs near the aphelion of the orbit.* This part of my chart of Mars will probably require more correction than any other part. In fact, from observations by Messrs. Green and Knobel (four of the latter I have given in the article Astronomy "Encycl. Brit.") it appears

* See Pl. xxvii. vol. ii. "Encycl. Brit.," (article *Astronomy*), which I have reduced from my chart of the orbits of the planets Mars, Earth, Venus and Mercury.

already that there is a large sea-region to the north of Dawes Strait, not shown in my chart. There is also a sea running southwards out of Nasmyth Inlet into Dawes Continent; and there are some reasons for believing that Nasmyth Inlet runs into Tycho Sea.

The following points have been indicated by Dr. Terby of Louvain, with regard to the regions just mentioned, as likely to need correction in my chart of Mars. In the main I agree with him.

1. As to the form of Tycho Sea and Delambre Sea. Is it probable, Dr. Terby asks, that those seas are as shown in my chart, or have they the extension indicated in the drawings of Knobel. Green, and others in 1871 and 1873? In other words, is Rosse Land a permanent isthmus, or was the light streak seen there by Dawes only owing to a passing cloud? I have already shown why I think the latter view the more probable.

2. What are the relations between the seas of Tycho and Nasmyth Inlet, Beer Sea, &c.?

3. The exact configuration of the two dark bands which connect the seas of Tycho and Delambre with regions further west, requires to be determined; may they not be simply the prolongations of those two seas, which in reality only meet on the eastern side?

4. What is the exact form of the faint prolongation of Tycho Sea towards the east, and what are its relations with Airy Sea.

5. To verify the solution of continuity between Tycho Sea and this faint prolongation.

6. To verify the existence of Lassell Sea and Leverrier Sea, of which no certain traces can be perceived in any drawings except those by Mr. Dawes.

7. To study the polar sea of Schröter.

8. To study the white region which Knobel and Green perceived immediately to the right of the Sea of Tycho.

He gives a similar series of questions relating to six principal line series of the planet's surface. I do not quote all his questions for want of space. The above series will indicate their general nature; the observer of Mars who notes with care the various and often varying features of the chief regions of the planet, should forward his pictures or tracings of them either to Dr. Terby, of Louvain, or to the Astronomical Society. It would be desirable to classify them in the way suggested by Dr. Terby, viz., with reference to the following six regions:—

1. Kaiser Sea and Dawes Ocean, with their chief dependent features, extending between 30° and 120° of areographic longitude in my chart. (In Marth's ephemeris published in the

April number of the 'Monthly Notices,' longitudes are measured from the first meridian eastwards, not westwards, as in Mädler's chart, which in this respect I followed.) The northerly limit of this region is in lat. 45°.

2. The region including J. Herschel Strait, Arago Strait, and Newton Strait, extending about 30° east and west of the first meridian, which passes through Dawes Forked Bay.

3. De la Rue Ocean with Dawes Sea and Lockyer Sea, extending as far east as Bessel Inlet. It extends between 240° and 330° longitude, and reaches to 30° north lat.

4. Hooke Sea and Maraldi Sea, with Huggins Inlet, Huyghens Sea and Bessel Inlet. Between 120° and 240° long. and reaching to 30° N. lat.

5. Tycho and Delambre Seas, and the northern part of Dawes Strait ("I have made a special study of this," says Dr. Terby, "as the least known of the Martial regions," for which reason I have given all his questions relating to this region.)

6. Beer, Airy, and Schröter Seas, Oudeman's Inlet, and their relations with Bessel Inlet and Huggins Inlet.

The two last regions complete the surface of the planet, extending from 30° north latitude to the northern pole.

Great interest will attach to the study of such changes as may be produced by the formation and dissipation of clouds over the surface of Mars, or the melting of snows either with the progress of the Martian year or possibly even during the course of the Martian day. The approaching opposition occurs about a fortnight before Martian midsummer for the southern hemisphere, the date of which is about September 18. As the melting of the snows which surround the southern hemisphere will probably reduce that snow-cap to a minimum about a month later, observers will have a very favourable opportunity of studying the reduction of the southern snows. Moreover, the smallness of the snow-cap will render it easier to ascertain whether its centre is coincident with the south pole, or, as is now generally believed, measurably displaced from that point. Observations directed to this end cannot but be regarded as extremely interesting. They will not only help to determine the true position of the Martian pole, but also to indicate the position of some of the midsummer isotherms for the southern hemisphere. According to the observations heretofore made, it would appear that the southern snow-cap reaches furthest from the pole in about longitude 30° east of the first meridian.

A few words may be added here respecting the nomenclature in my map. When I was constructing my chart of Mars, I proposed to write a treatise upon the planet. That was in

1867. A letter from the late Professor Phillips to Messrs. Longmans, dissuading them from taking the risk of such a work, and my inability at the time to incur the expense of it myself, caused me to give up the idea. Later a pressure of many other engagements has interfered with my intended resumption of the scheme. But it was the circumstance that I had such a work at that time in preparation,* which led me to add names to my chart of Mars; because in the accounts which I should have had to give of the various features of the planet, names would have been convenient if not absolutely necessary. The rule which I adopted in the selection of names was simply to assign to the chief features of the planet the names of observers who had detected such features; to features next in importance the names of observers who had extended, but not in equal degree, our knowledge of the planet's surface; and to minor features the names of those who had advanced our knowledge of the theory of the planet. This was done simply for convenience. Some principles had to be adopted, and the above seemed as good as any which occurred to me. There was no idea of recognition of the labours of the various observers or mathematicians in question. It has always seemed to me that such ideas are absurd, and almost childish. As the chart was almost entirely formed from drawings by Dawes (though I studied many others), and as he expressed a wish that his name might be given to certain minor features which he alone had observed, as Dawes Forked Bay, Dawes Snow Island, Dawes Strait (which last, however, has been seen, I have since found, by Lehardelay, Secchi, and others) his name appears several times in the chart. Other names appear more than once. This I now think a mistake, and propose to correct, taking counsel to that end with Dr. Terby, and others who have recently endeavoured independently to advance Areography.

But, in the meantime, M. Flammarion, who has not advanced our knowledge of Mars by observation or calculation, or has at least published no account of work to that end, has formed what he calls a new chart of the planet, which is, in point of fact, simply my own chart changed according to Dr. Terby's suggestions of what *may* have to be done in this way. In this new chart, the nomenclature is entirely altered. "The principle of 'recognition' or of 'homage' to the great men who &c. &c." is taken as the basis of the new nomenclature. Those who have enabled us by their observations to chart the planet are relegated to small bays and peninsulas, while to those who have advanced

* I hope to be able shortly to carry out that purpose, and probably the work will not suffer by the delay.

astronomy generally (who are far too numerous for the purpose) are assigned the oceans, seas, continents, and lands of the planet. The chart as a whole, thus modified, becomes M. Flammarion's chart! "La carte que je viens de tracer," he says, "est donc en realité un cinquième essai." Elle "représente exactement * l'état actuel de nos connaissances sur la géographie de ce monde voisin." In reply to Dr. Terby's somewhat energetic reclamation on his own behalf and mine, M. Flammarion coolly rejoins that Riccioli's nomenclature replaced that of Hevelius, and not improbably his will replace mine. This may or may not happen, and in itself it matters little which nomenclature is adopted, so that confusion be avoided. But the reference to Riccioli is a little unfortunate. The following passage in my "Moon" was written three years before M. Flammarion's new chart was formed, and certainly without any expectation that it would ever be useful to point a moral; M. Flammarion would hardly wish to have his new names adopted in the same way as Riccioli's, as thus described:—"Father Riccioli of Bologna published in 1651 a much less valuable chart than that of Hevelius. He adopted a new system of nomenclature, replacing the terrestrial names of Hevelius by the names of astronomers and philosophers. Mädler says, indeed, that Riccioli's work would have been forgotten, had he not been led by vanity to find a place for his own name on the moon—an arrangement only to be achieved by displacing all the names used by Hevelius, at the risk of causing perplexity and confusion to later astronomers. The charge is rather a serious one." Strangely enough M. Flammarion has in the most marked way left the most striking feature of Mars—the Kaiser Sea—with no other name than Mer du Sablier or Hour-Glass Sea. Whether the hint will be taken remains to be seen.

* Dr. Terby considers the corrected chart inferior in accuracy to mine, and after the study of a great number of views of the planet, I feel confidence in asserting that Dr. Terby's opinion is just. Some of the features as drawn by M. Flammarion are scarcely recognizable.

EXPLANATION OF PLATE VII.

Six stages of Martian rotation, separated by 60° or four hours of Martian time. In fig. 2, the first meridian of the chart passes about 30° east of the centre of the figure.

THE VOLCANOS OF THE HAUTE LOIRE AND THE ARDÊCHE.

BY THE REV. W. S. SYMONDS, OF PENDOCK.

[PLATE VIII.*]

SO vast are the accumulations of volcanic materials of different ages in Auvergne which have burst out through the old granitic land that bordered the eocene and miocene lakes of the Limagne, that we are apt to ignore the granite masses which constituted the ancient country through which generally the volcanos of different ages burst. When, however, we visit the higher regions of the Forez, the Haute Loire, the Ardêche, and the Cevennes, we pay more attention to these mountain masses of crystalline rocks, they gain on our respect, and we wish to know something of the time of their elevation and their claim to antiquity. Mr. Scrope directed attention to the great frame of secondary rocks which surrounds the upheaved granite country. These secondary rocks include an extensive series of strata which are now known to be of Liassic, Oolitic, and Cretaceous ages. In some localities, as in the Cevennes, these limestone strata are tilted with the granite rocks, and attain to a very considerable elevation, while in others towards the north-west they decline with the granitic rocks. In the Ardêche, in the Coiron mountains, they occupy a wide and nearly horizontal table-land, and have been overflowed by basalt and protected from denudation. Here the upper beds are of lower Cretaceous age, and the question arises in the mind of the lover of physical geology, Did the Cretaceous and Jurassic seas once roll their waters over the country of the Auvergne, where now rise the heights of Monts Dôme, Mont Dore, the Cantal, the Forez, and the Haute Loire? or was this granite country an island even in those far distant epochs? I have directed attention, in my paper on the Auvergne country, to the occurrence of Eocene species of mammalia in freshwater beds, at Gannat and Le

* This plate, containing a sketch-map of the district, will be published with the concluding portion of the article.

Puy en Velay, and it is well to bear in mind that the elevation of some of the highest mountain ranges in the world has taken place since the Eocene epoch. We have picked up Eocene fossils at a height of nearly 10,000 feet on the Swiss Alps, and friends have sent us specimens from the height of 20,000 feet from the mountains of Thibet. In Europe, in Asia, in Africa, the stony relics of animals which once flourished in the deep waters of the Eocene seas are now elevated thousands of feet above the level of the plains. The very sites of great cities, such as London and Paris, are crowded with the fossil remains of animals which lived on Eocene lands, or frequented Eocene waters, and whose forms and shapes testify to the vast climatal changes which have happened in our latitudes since they lived and died. The mammalia of that epoch were so strange in form and structure that it is difficult to recognize in them any relation to existing species. The palæotheres, which frequented the shores of seas, estuaries, or lakes, where are now the Isle of Wight, London, Paris, and Auvergne, were types of the existing rhinoceres, tapir, and horse; and the Hyænodon which preyed upon them, and whose remains have been found in Hampshire and in Auvergne, was a carnivore which combined the destructive energies of the wolf, the hyæna, and the tiger. Then as regards the plants. The Eocene plants of these latitudes were of sub-tropical types and genera, and have almost altogether disappeared from lands whose climate is no longer adapted to the palm, the cinnamon, and the custard fruit. With them, too, have disappeared from the seas the turtle, the great sub-tropical shark, with numerous forms of sub-tropical shells; and the crocodile no longer haunts our lakes or rivers, as it did when the gypsum of Montmartre was accumulating where now is that Parisian hill.

It is impossible to visit the museums in Paris and see there the relics of mammalia, reptiles, and birds which have been found in Upper Eocene lacustrine beds, and the shells and other remains of marine animals which lived in the Lower Eocene seas, without feeling sure that Eocene lands as well as waters were teeming with life. Fifty extinct types of mammalia have been found in the Paris gypsum alone. And yet all we know of the land-life of the Eocene epoch may be said to be furnished by a set of quarries which in France and England together would not occupy a square mile of ground. No wonder Sir Charles Lyell insisted on the imperfection of the record. Now the Miocene strata of the Continent, so poorly represented in Great Britain, afford many more fossil remains of land animals attesting the existence of Continental areas inhabited by vast numbers of quadrupeds, which lived on the borders of ancient rivers, and whose remains are found in the silts of

ancient rivers and lakes. The hordes of the Persian tyrant when he burnt Athens could hardly have been more numerous than the swarms of animals, mastodons, dinotheres, hipparions, and giraffes, which frequented the Miocene plains, where now stands Athens, and where now rise the mountains of Greece. In France, Switzerland, and Germany are freshwater strata, the silts of ancient Miocene lakes, which all tell a similar history of the existence in European areas of widespreading Miocene lands.

There has always been a good deal of difficulty about the separation between the Miocene and Eocene formations. In the country around Paris, French geologists drew the line at the Fontainebleau sands, and placed the Montmartre gypsum and its mammalia as the summit of the Eocene series. The Montmartre beds belong to a *freshwater series*, and the Fontainebleau (Miocene) sands are marine, and full of a characteristic shell, namely, *Ostrea cyathula*. Sir Charles Lyell formerly objected to this division, but admitted it as the only one agreeing with the distribution of the Eocene and Miocene mammalia; which, after all, must be the most important test, as the mollusca are known to be so much longer lived as regards geological time. I mention these circumstances because marine shells of the Miocene age are said to have been found near Issoire and Le Puy en Velay; while the Eocene silts which contain Eocene mammalia both in Auvergne and at Le Puy en Velay are undoubtedly freshwater. The traveller may reach Le Puy en Velay by rail from Lyons by St. Etienne; but we advise the route by Issoire and Brioude from Clermont Ferrand. Issoire, the ancient Issiodorum or Issidore, was a place of considerable importance in Roman times and the residence of a prætor. The church is remarkable for its size, stateliness, and decoration in colours. It is a fine specimen of Romanesque architecture, from its circular eastern apse to its western front, which is, like our early Norman, quite plain, with billet moulding round the arches. Over the square front is a square tower, with two rows of round-headed windows, and in the centre is an octagonal tower, likewise showing two rows of windows besides a short spire. Within the church the great height and length are very imposing, and the date of the building is reputed to be A.D. 939.

I have alluded in my former paper to the geology of Issoire. It appears to me that there is still much to learn. The Puy Barnère is the highest elevation at which the tertiary freshwater strata are found in all Auvergne, and Mr. Scrope makes the height to be 2,730 feet above the sea. This hill should be visited in order to see the basalt resting at this height on dense masses of freshwater limestones and marls. But the most important researches in the Issoire district are those which would lead to a thorough investigation and correlation of the various

positions of the different alluviums, breccias, gravels, and drifts of the country, for nowhere do we find the excavation of valleys more marked by older and newer gravels, as well as by the position of older and newer lava sheets. Nowhere can we study better the masses of conglomeratic alluvia which descended the valleys, and are so largely developed at the Dent du Marais near Lac Chambon, at Necher and Champeix. Unfortunately when at Issoire I had little time to examine the physical position of these various alluvia and drifts, although I had notes of localities where certain species of mammalia have been found. Two kinds of marmot (*Spermophilus* and *Arctomys*), have been discovered in drifts or breccias near Issoire, at Paix, Coude, and Champeix, and with these were found the lagomys, or arctic tailless hare of Siberia, now no longer living in Europe, and remains of the mammoth. The caves of Champeix, too, have yielded the remains of bear (*Ursus spelæus*), badger (*Meles*), and horse. Hyæna also has been found in this district. With respect to the Pliocene mammalia, they have been found in great abundance in the tuffs and breccias of Mont Perrier, and with them are *Mastodon arvernensis*, *Elephas meridionalis*, *Rhinoceros etruscus*, *Hippopotamus major*, and the great tiger, *Machairodus cultridens*, most of which occur in the forest beds of Norfolk. Mr. Scrope informs us that the researches of MM. Croizet, Bravard, and Pomel indicate that the remains of mammalia from the bone beds of Mont Perrier belong to successive tertiary epochs, and that there are distinct assemblages of species preserved in the different bone breccias; in short, that there are Mont Perrier stratified tuffs and breccias of Miocene age containing Miocene animals, and Pliocene tuffs and breccias containing Pliocene quadrupeds. But this is not easy to understand, for it is evident that the old Miocene basalts, which now are found high up upon hills, had been excavated, and deep valleys cut through them into the freshwater strata, long before the lower bone-bearing gravel drifts and the Mont Perrier tuffs which overlie them had been deposited. It seems to me that the remains of the Miocene animals in the Mont Perrier tuffs were probably washed out of older strata, and were buried in the flows of mud which accompanied the later volcanic eruptions which burst out in Pliocene times. There are no phenomena in Auvergne so puzzling as these conglomerates and breccias. How masses of trachyte from Mont Dore and prisms of basalt, unworn, and with their angles uninjured, arrived at such positions, as the Puy de Monton, twenty miles from the Pic de Sancy, it is very difficult to say. In the neighbourhood of these mud breccias, too, it is well to be careful about attributing the transportation of rock masses to the action of a glacier, for in some instances the mud has been washed out and

the blocks left stranded. This may be seen in the neighbourhood of the Dent du Marais. Up the Allier from Issoire is Brassac. This Carboniferous outlier is separated by a great tract of elevated granitoid gneiss from the coalfield of St. Etienne miles away to the eastward on the right bank of the Loire. It lies in a hollow of granitoid gneiss, and is overlain on the west by the tertiary freshwater marls, which near Ardes to the westward are themselves overlain by basalt. Volcanic outbursts of comparatively late date, have penetrated through Carboniferous rocks, tertiary marls, and granite in this district, and are seen in masses of scoriæ and peperino. Le Vernet, famous for its amethysts, lies to the north-east of Brassac, and is situated on granitoid gneiss.

Brioude is not quite half-way between Issoire and Le Puy. It was once a Roman settlement, and in later centuries suffered from the ravages of many armies which from time to time desolated France, and from the proscriptions, wars, and massacres which accompanied the suppression of the Huguenots and their love of civil and religious freedom in Haute Auvergne. Brioude is now an old rambling town, quaint, odoriferous, and dirty, with houses which once saw better days, and apparently belonged to wealthier inhabitants. The site of the church is believed to have been occupied by a Roman temple, and the Christian forms of worship to have been established here in the old home of paganism. The portal is very fine, and the revolutions which time has wrought have not been able altogether to efface the ecclesiastical monument of bygone centuries. Here we have the southward prolongation of the tertiary freshwater strata of the Limagne and of the valley of the Allier, and here the granitic gneiss, through which the river flows so many miles from its source, abuts against the stream, and rises to the south in the Montagnes de la Margeride, and the mountains of the Haute Loire. In this elevated region rise, not only the Allier and the Loire which flow northwards, but the Ardêche, Erioux, and many streams which flow to the Rhone. At Vielle Brioude we cross the Allier by a fine bridge, but the river is subject to such violent floods that its bridge and railway are exposed to considerable danger. In 1824 the old bridge of Vielle Brioude fell wholesale into the Allier. A little west of the village of Vielle Brioude is the village of Sempole. This place and the ruined Castle of Massiac are built on outliers of a current of basalt which flowed from the great Etna-like volcano of the Cantal on the south-west. In fact, the stream divides the volcanic outbursts of the Cantal from those of Langeac and Le Puy.

In the fifth century, in the days of Clovis and Childebert, Brioude was considered a place of importance, and Auvergne a rich and tempting land. Gibbon says that "the sides of the hills were clothed with vines, and each eminence was crowned

with a villa or castle;" and relates, on the authority of Gregory of Tours, how Theodoric, the eldest son of Clovis, led his troops, reinforced by the fiercest barbarians of Germany, and spread desolation over the fruitful face of Auvergne. Two places only, a strong castle and a holy shrine, were saved or redeemed from their licentious fury. The fortress he fixes on was at a place called "Castel Merliac, two miles from Mauriac." At all events, the higher rocks and commanding situations appear to have everywhere been fortified at an early period, as the Puy Dallet near Clermont. On the occasion alluded to, the church of Brioude was sacked, and a division made of the spoils at a small distance from the town.

To the west of Brioude are the high granite summits of Le Forez near La Chaise Dieu, where rise numerous tributary streams both of the Allier and the Loire. This is a wild inhospitable district, with forests of fir still tenanted by wolves. Here, too, as in Cevennes, the Huguenots, when they became an isolated and proscribed race, often took shelter, during the Reign of Terror in the days of Louis XIV. The singular village of La Chaise Dieu was once famous for its Benedictine abbey, founded as early as 1452 by a canon of Brioude, who was afterwards looked upon as a saint, under the title of St. Robert. The once extensive monastery is now desolate enough, the great tower and some melancholy buildings attached to it being all that remains. The church is remarkable for its size, its fine windows, carved oak, and a fine tomb and figure of Clement VI. But where are the worshippers? All is mouldering and damp, and the country around is wild and drear, the granitic gneiss weathering into a poor unfertile soil, traversed by torrents, which in rainy weather turn the Loire and Allier into roaring floods.

Nevertheless, the geologist may in this district gather a good deal of information as to the physical conformation of the country long, long ago. He may roam among those granite heights and restore in imagination the features of the country, even as far back as Eocene times, before the mountains of Cantal, Mont Dore, or Monts Dôme, now such grand features in the landscape, had any existence. No doubt long ages of denudation have planed down the peaks and precipices of the old granitic mountains; but there stand "the eternal hills," their forms and features greatly changed perhaps, but looking down now from the most elevated heights upon towns and villages where once flowed the waters of fresh-water lakes. By the shores of the old lake of Le Puy the long extinct forms of the palæothere and anoplothere might have been seen roaming about; and the gazelle-like xiphodon was chased by the hyænodon over the granite mountains which rose above the lakes.

Then in later times (Miocene) those same mountains were the haunt of mastodons and rhinoceroses, the hipparion, and the stag; and the dinothere frequented the waters of Miocene lakes, which were in existence when the Cantal was vomiting forth its volcanic fires, and Mont Dore was sending forth streams of lava twenty miles in length.

On crossing the Allier from Vielle Brioude on our way to Le Puy, we pass over the base of the granitic rocks which rise into the mountains of La Chaise Dieu and Le Forez. Here and there deep wooded ravines diversify the scene, and at Paulhagnet we come upon recent volcanic masses which have burst through the granitic rocks, and which probably belong to the same age as the outbursts of the Puys de Dôme near Clermont. Near a place called Fix, the granite rocks appear again, and soon after we strike the volcanic eruptions of Mont Denise, and those around Le Puy. The most unimaginative sightseer can hardly look upon Le Puy en Velay without feeling a thrill when his eye rests for the first time upon that city with its Cathedral and its great pyramidal rock masses, the Rocher de Corneille and St. Michel. Le Puy is a strikingly picturesque town, with its lofty cathedral and two pyramids of rock, the one sadly defaced by a great coarse-looking statue in bronzed iron of the Virgin; the other surmounted by a strange old church. The town is built on the south side of Mont Anis in the form of an amphitheatre, and the Place de Meriel is a fine square with public buildings, while the streets are many of them narrow and odoriferous. The first impulse of the traveller is to make his way to one of the rock pyramids which he sees rising from the town; but which the narrowness of the streets and height of the houses hide from his view when exploring the streets themselves. The Cathedral stands below the Rocher de Corneille at the head of some steep streets. Portions of this venerable church are said to date from the eighth century, after the Saracens had been driven beyond the Pyrenees by Charles Martel (A.D. 732). The portico at the western entrance is grand. Flight after flight of stone steps must be ascended before we enter the lofty portal of noble vaulted arches, supported on pillars of Romanesque character. The doors under two side arches are carved with rude figures, said to be of great antiquity. The interior of the church is similar in character to the other early churches of Auvergne, with the exception of the vault, which is divided into two bays, each of which is domed. The interior of the building is degraded by a number of trashy pictures. We went near to the image of the Black Virgin of Le Puy, as no service was going on, and saw also a large painting of a procession of bishops, priests, and public functionaries, on the occasion of a jubilee. The literature on this subject

fills whole volumes. The image which now stands over the high altar is a new one, the original having been burnt in the Revolution of 1792, but we afterwards saw some curious relics of the original figure in the museum. These consist of the folds of papyrus which once enveloped the original Black Virgin. The sheets of papyrus bear Egyptian or Arabic inscriptions, and the figure itself was recorded to be of brown cedar wood, and with it was also said to be a conical stone bearing Arabic characters. M. Maudet, the historian of the civil wars of Le Velay, has given the most reliable information respecting this image and its history. Many have been the disputes as to the donor of the figure. The gift has been attributed to Dagobert, Charlemagne, and Philip Augustus, also to St. Louis. The general view now taken by the antiquarian is that the Black Virgin was originally an ancient eastern idol or image of Isis, of whose worship Le Puy, anciently Anis, the Aniscum of the Romans, was a great centre. It is not impossible that the Black Virgin was the object of worship before the days of the "Holy Martin," bishop of Tours, and his crusade against idols (A.D. 381).

St. Michel is a very picturesque rock rising to a height of nearly 300 feet, its diameter being only 400 feet. Steps cut in the solid rock lead to the church which crosses the summit; and near the base of the rock are the remains of a Roman temple to Diana, now in a sad state of neglect. The portal of the little church of St. Michel, on the summit of the rock, has a round arch enclosed within one of trifoliated design, and figures are carved about the doorway. On the west side is a semicircular choir, supported by Romanesque pillars, low, and carved in bas-relief.

The Church of St. Laurent at the northern entrance to Le Puy has only one object worth mentioning. This is the fine tomb of the noble constable of France, Bertrand de Guesclin. The celebrated soldier reclines at full length in armour of plate without his helmet. On his shield he bears a double-headed eagle. He is styled "Messire Bertram dankin." This tomb takes us back to the days of our own "Black Prince" and "Pedro the Cruel," and was erected to perpetuate the memory of "the most valiant knight, the most expert leader, the most fortunate and successful warrior who fought under the banner of France."

Before examining the country around we recommend a visit to the Museum of Le Puy, which is a large and handsome building. There are many objects of interest in the collection of Gallo-Roman relics from buildings, hypocausts, and tombs, and especially we noted a set of instruments of a Roman or Gallo-Roman oculist—scalpels of different form, forceps, tweezers, &c.—all finished with great care, and showing that even in those

times ophthalmic surgery had made considerable progress. The geological and mineralogical collection occupies a separate compartment, and should be studied before examining the geology of the surrounding district. In this communication we can only direct attention to some of the most remarkable mammalian fossils, and to the localities from whence they came, which we learnt either from labels attached to them or from the curator. From the drifts of Denise and near Polignac have been obtained bones and teeth of the mammoth and *Elephas primigenius*; from volcanic breccias near Solignac are remains of *Elephas meridionalis* and two species of *Rhinoceros* (*R. leptorhinus* and *megarhinus*, with bones and horns of a great stag. From Vialette we find *Mastodon Ronzoni*, *Rhinoceros etruscus*, and *Tapirus arvernensis*. From Ronzon we find *Cynodon velaunus* (with huge carnivorous teeth) and *Bothriodon*. From the marls and clays of Mont Anis and Corneille are the Eocene forms of two Palæotheres. These specimens are in the galleries. The strata which yielded the Eocene relics also yielded the eggs of water birds, the remains of reptilia, with some freshwater shells, such as *Lymnea* and *Paludina*, and the valves of *Cypris*. M. Aymard, in a paper read by him before the Scientific Congress of France at Le Puy, in 1855, fully recognized the lowest tertiary marls and clays of the basin of Le Puy to be of Eocene age, and he has also endeavoured to establish a triple division of the tertiary strata, viz., Eocene, Miocene, and Pliocene, as well as Postpliocene breccias, and his views are most important from his acquaintance with all the localities in which the bones were found. It is to be regretted that a better arrangement is not adopted in the museum, for different groups of bones have evidently got intermixed, and many of the best specimens are without names or the localities where they were discovered. With regard to the celebrated fossil human bones of Denise, we were disappointed. In the first place, the bones looked too fresh. In the second place, they are described as occurring in "a block of breccia," whereas they occur in a laminated sandy mass, with a mixture of lime. I have especially directed attention, in "Nature" (January 13, 1876), to an "iliac" bone in the museum. It rests between stalagmitic layers, as if the bone had been washed into a fissure through which percolated water, charged with lime. I shall endeavour now to direct attention to points which the geologist should visit in succession if he would become acquainted with the geology of the district.

Having seen the remains of glacial and northern animals in the museum, and learned that my friends Sir Wm. Guise and Mr. Lucy had, on a former visit, detected drifts with angular fragments near Polignac, which might be the beds indicated by

Mr. Scrope as containing bones of these animals, one of our first visits was to Polignac and Mont Denise. The rock of Polignac is one of those strange pyramidal rocks of basaltic breccia similar to the Rochers de Corneille and St. Michel at Le Puy. The Castle, of which little remains save the great tower and donjon keep, was once an important feudal stronghold, the abode of a race of tyrants who were the terror of the surrounding country. It was built upon a Roman site, for in the museum at Le Puy are many Roman relics which were found among its mouldering walls. The site is now overgrown with low shrubs, grass, and wild flowers, among which there still lies a slab of stone with a Roman inscription of the time of Tiberius, and a large bearded head which appears to be that of Jupiter, the mouth of which has evidently been used as a spout. South of the castle, at a short distance to the right of the road, near a place marked by a cross, is a ridge of consolidated drift, regularly stratified, containing lumps of granite, some as large as cannon balls, with fragments of lava. Two visits which we afterwards made over and around Mont Denise convinced me that this conglomerate is a diluvium made up of rock fragments washed down from above, and that it occupies at Denise fissures and hollows which are the localities, in all probability, from which the teeth and bones of the mammoth were obtained. The granite, before it was drifted, was, I do not doubt, blown out by volcanic explosions, as fragments are found on the surface of Mont Denise.

I think it necessary to separate these aqueous drifts and stratified conglomerates with mammoth remains from the volcanic muds and breccias. They look much more like those drifts which are the result of melting snows and running water, and it is important to remark them whenever they occur, as belonging to the period we term glacial. They not only occur in valleys, as below Polignac, but are heaped against the sides of the hill of Denise, above Polignac, and Captain Price and I found them beyond "the Chimney," on the road to Brioude, high up on the western flank of Mont Denise, and again on the north-east flank of the hill near the peperino quarries. L'Hermitage is the name of a little hostel below Mont Denise, on the road from Le Puy to Brioude, and it was near this place that the human skull and other bones in the Museum of Le Puy were said to have been found in a block of breccia. As I have already hinted, we never liked the look of these human bones, and since investigating the site whence, as we were told, they came, we liked them less than ever. We were conducted by the man who declares he found them when digging a well near the little auberge where he now resides, and he showed us the spot above the well, now built over by a wall, where the

remains of the skeleton lay. The locality given by Mr. Scrope in his sketch appears to be higher up the hill. Sir C. Lyell was also conducted to a place "not far from the summit of the volcano," but the well of the Hermitage is a long way from the summit of Mont Denise. We went from the museum to Denise, and again from Denise to the museum, on two separate occasions, and I convinced my companions as well as myself that the human bones were never enveloped in breccia, nor was the matrix of the mass in which they lie in the least like the breccia of the well of the Hermitage. I have already mentioned that some of the bones lie in a matrix which looks as if it was derived from a wash of volcanic materials, intermingled with lime, forming a kind of stalagmite; and as I dislike throwing entire discredit upon the word of the peasant who found them, I would suggest for future explorers the examination of the site for some distance above the well. It is not improbable that these human bones were washed into a crack or fissure, through which the water percolates downwards to the well of the Hermitage. The geology of Mont Denise beyond the "Croix de Paille" is of high interest. "The Chimney" section shows the older breccias, or stratified volcanic mud (peperino), blown away, and a great vent filled with red and black cinders. This last explosion of Denise was not apparently attended by any outflows of lava, but by violent discharges of volcanic cinders, dust, and bombs. The vent is well marked, the stratified older peperino presenting a wall-like line where the beds in the vent were blown away by explosive forces from below. While examining this remarkable section in detail we were struck by some yellowish-looking beds, which are seen resting in a hollow a little to the west of "the Chimney." These are, I believe, alluvial breccias or drifts of the same age and character as those near Polignac, and on the north-east flank of Denise. Another point also struck us, viz., that the explosions through "the Chimney" appear to be of later date than those drifts, for the black and red cinders are seen to overlie them higher up the hill.

(*To be continued.*)

NOTES ON THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

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THE study of the geographical distribution of living and extinct organisms has recently become one of the most important branches of philosophical natural history, from the light which it throws both on the former condition of the earth, and on the greatest scientific question of the day, namely, that of the origin of species. The geographical distribution of animals has lately received much attention, the most important contribution to the subject being a large work by Mr. A. R. Wallace; but in the present paper we propose to bring together such observations as may prove interesting, either from their importance or from their having been less fully discussed elsewhere.

Most naturalists are now agreed in recognising six main regions of geographical distribution, as originally proposed by Dr. Sclater, viz. the Palæarctic, Ethiopian (or African), Indian (or Oriental), Australian, Neotropical (or tropical American), and Nearctic (or North American) regions. The Palæarctic region includes Europe, North Africa, the northern half of Arabia, and the whole of Western and Northern Asia, as far as the Indus and Himalayas, and a line drawn eastwards, running south of Thibet and Mongolia, and somewhat north of Formosa. The Indian region includes, besides South Asia, the large islands of Borneo, Java, Sumatra, and the Philippines; but the islands further to the east belong to the Australian region. The Neotropical region includes the West Indies, Central and South America, and the south of Mexico; the remaining regions require no further explanation.

Although these regions are generally recognised as natural, we must not consider the divisions between them as hard and fast lines, except that between the Indian and Australian regions, where the island of Celebes is almost the only de-

batable ground. Indeed, the fauna of much of the west coast of America, especially that of California and Chili, exhibits such marked affinities with that of the Palæarctic region, that these countries have been regarded by some writers rather as outlying districts of the latter than as biological portions of the continents to which they actually belong. It is also to be observed that this division of the world into six main regions is more applicable to some groups of animals and plants than to others. Various attempts have been made to subdivide the regions, but though some subdivisions, such as the Mediterranean subregion, are eminently natural, our knowledge of the natural productions of most of the regions is not yet sufficiently exact to allow of their being divided in such a manner as to gain the general assent of naturalists.

Owing to the much greater competition of rival forms in large continents, the larger and more highly developed forms always appear to have originated and been brought to relative perfection on the greatest continuous districts of land. But notwithstanding the frequent alterations of level during geological ages, which have constantly united or separated various portions of the earth's surface, yet it appears that the largest masses of land, though differing in outline and continuity, have always occupied nearly the same places; that is, it is more probable that the contour of former continents has been changed by gradual increase or diminution, than that a whole continent should be submerged or elevated *de novo*. It also appears that the northern hemisphere, and more especially the Palæarctic region, has been the birthplace of most of the principal groups of animals, including those now confined to tropical Africa, or even to South America.* Nor need this surprise us, poor as is the present Palæarctic region, when we consider the great vicissitudes to which this region has been more especially exposed, and the many conditions unfavourable to animal life which it now presents. There is little doubt that the amazingly rich fauna possessed by Europe previous to the glacial epoch was then almost entirely swept out of it, a very large proportion of its original fauna and flora being either wholly exterminated or driven into distant regions, whence, on the abatement of the cold, their descendants would return very slowly, if at all. Besides, it is urged by Mr. Belt that during the glacial period such vast masses of water were locked up in snow and ice that the average level of the sea

* This is confirmed even by groups of which very few fossil remains exist. Mr. S. H. Scudder, in his recent work on fossil butterflies, only admits nine species, all European; but of these four are preponderatingly American in their affinities, three Oriental, one Mediterranean, and one African.

would be at least 1,000 feet lower than at present, and probably far more. This would lay bare great tracts of land possessing a much warmer climate than any other portion of the globe at that time, where many tropical forms may have survived the glacial period, though some would doubtless have been subsequently exterminated by the great floods which Mr. Belt argues would have occurred towards its close, from the melting of the ice. This view receives considerable support from the numerous traditions of submerged countries in the Atlantic, and off the coasts of China, India, Ceylon, and East Africa.

Great changes have recently taken place in the inland seas of the Palæarctic region. It was formerly bounded to the south by a great inland sea, resembling the Mediterranean, occupying the place of the Sahara; and a chain of inland lakes appears to have extended from Spain to the Black Sea. Wallace believes the Mediterranean to have then consisted of two great lakes, while North Africa was connected with Spain and Italy by extensive tracts of land now submerged. At this time, too, much of Northern Asia may have been depressed below the sea, or, at any rate, the great lakes, such as the Caspian, Aral, and Baikal, appear to have communicated with the Arctic Ocean. But there is still much obscurity relating to the geological history of Northern Asia: and until increased facilities of communication and changes in politics render China and Asiatic Russia more accessible to scientific men, it cannot be entirely cleared up. It is so difficult to account for the total disappearance of such forms as the mammoth from a country like Siberia, that some have suggested that they were destroyed by floods, to which indeed a great part of Central and Northern Asia was very probably subject, considering the much greater number and extent of the inland seas in former times, even if a large portion of the country was not actually covered by the Arctic Ocean. Much valuable geological information relating to Northern Asia in recent times must be still locked up in Chinese annals; and I have not yet met with any history by a competent geologist of the series of great volcanic disturbances, inclusive of earthquakes and floods, which devastated China during the first half of the fourteenth century, and which were felt with great severity at least as far as Austria and Greenland, and indirectly over the whole of the then known world, and there is reason to believe even in America. A history of these extraordinary phenomena, which are unparalleled in modern times for their extent and severity, if collected from the numerous available materials, and worked up by a competent hand, would be of the greatest scientific value.*

* The most accessible account of this period is perhaps that in Hecker's History of the Black Death, in his "Epidemics of the Middle Ages."

And here I may remark that I am convinced that great light would probably be thrown on the former state of the world in historic times by the study of Oriental literature by scientific men. There has been much discussion among Orientalists about the identification of the islands of Wák-wák, mentioned by Arab geographers, as well as in the "Arabian Nights." These are the islands, seven years' journey from Baghdád, where the trees bear fruit in the shape of female heads, suspended by the hair, which cry out, "Wák-wák" at sunrise and sunset. Then, to connect these islands more distinctly with birds, they are inhabited by jinneeyehs, who fly about in feather-dresses, which are sometimes stolen by some enterprising hero. Wallace describes the great bird of Paradise (*Paradisea apoda*) as being very abundant in the Aru Islands, and settling on the trees in flocks at sunrise, uttering a loud and shrill note audible at a great distance, which sounds like "wawk-wawk-wawk-wŏk-wŏk-wŏk." Anyone who will consult Lane's "Arabian Nights," vol. iii. chap. 25, note 32, and Wallace's account of the Great Bird of Paradise, in his "Malay Archipelago," chap. 38, will, I think, be convinced, like myself, of the identity of the Aru Islands with the islands of Wák-wák of the Arabian writers.* But even when animals are spoken of under their proper names, it will often be no easy matter to identify them in a translation; for I have generally found that the English, French, and German equivalents for the vernacular names of common animals or plants are rarely to be ascertained with any accuracy from the best existing dictionaries; and this difficulty would be greatly increased in the case of Oriental or ancient writings, in which animals, perhaps now extinct, would frequently be described in very hyperbolical language.

To return from this digression to Europe, we need not wonder that its present fauna is so much poorer than in post-glacial times, or even than a few centuries ago. The advance of cultivation, the felling of forests, and the draining of marshes have exterminated many species, even in our own day, while others have been destroyed as noxious creatures, as the wolf in Britain, and the lion in Germany† and Greece. Others were exterminated for food, as the great auk in the northern regions; and the urus and aurochs, both now almost extinct, the former only existing as *Bos scoticus*, and the other in Lithuania and the Caucasus, the last being the only locality where it is still actually wild. As, however, these wild cattle

* I am not aware that the reputed occurrence of this bird in New Guinea has been confirmed; and the islands of Wák-wák are always spoken of in the plural.

† Which it is believed to have inhabited during the heroic age.

are fierce and dangerous animals, they may have been exterminated partly for this reason. A very interesting volume could be written on the animals which have disappeared from Europe within historic times. When the ancient world was overrun by huge and destructive animals, it must have been difficult for men to make any progress in civilization; but when the glacial epoch had swept all before it, it was much easier for men to improve their condition. So far as we know, the ancient centres of civilization, such as Central Asia and Egypt, were less overrun with wild beasts than others.

The islands of Corsica and Sardinia, though barely alluded to by Wallace, are interesting from the number of peculiar species which they already contain, and for the still larger number of local forms, which, if isolated for a sufficient time, will ultimately become perfectly distinct species. Their fauna appears to have been derived from the mainland of Italy at a period when that country was already fully stocked with its present fauna, as they possess a large proportion of the Italian species. They have apparently been separated from the mainland for a much longer period than Britain from France; for, although Guénée calls Britain "le pays des variétés," well-marked species have not yet had time to develop themselves. Here, however, other considerations step in. The much hotter and finer climate of Corsica and Sardinia may have stimulated the more rapid differentiation of species. And although we are still ignorant of many of the laws which govern the range of species, yet it appears from the large proportion of species common on the French coast, and not extending to Britain, that Britain was separated from France before France had fully acquired its present fauna and flora. The same reasoning will apply to Ireland, which is much poorer in species than Britain.

Some writers think that the Glacial Period has not wholly passed away, and that the earth has not yet recovered its normal temperature; and although it would require a long series of observations, extending over many years, if not centuries, to arrive at absolute certainty, yet there are some historical grounds for believing that the climate of all Europe was much more severe only 2,000 years ago than at present.* How far the clearing of forests, &c., may have influenced the climate we do not yet know, nor whether its gradual improvement is due to local or general causes. It is quite possible that the animals and plants now confined to Eastern, Southern, or Central Europe are still extending their range north and west, so far as they meet with no barriers to their further migrations.

* Compare Mallet's "Northern Antiquities," pp. 242, 243.

In the case of the British Islands, there are other conditions besides breaks of geographical continuity which hinder the spread of some species. The unfavourable climate of the northern and western portions is probably one cause of the restricted range of many species, and their total absence from Scotland, Ireland, and in many cases, even from the north or west of England. Nothing strikes a naturalist, accustomed to the comparative abundance of insect life, even in the south of England, than its usual scantiness in Ireland, although the latter country probably possesses about two-thirds of our English species.

The Mediterranean subregion presents us with several interesting problems, in addition to some previously mentioned. During the time that Spain and Italy have been separated from North Africa, great changes have occurred in the insects of the opposite coasts, as well as in the larger animals which now inhabit those countries. Oberthur, in his recently published work on the Lepidoptera of Algeria, doubts if any Algerian species of *Zygæna* is identical with any European species. This, however, might perhaps be expected, for the genus *Zygæna* consists of a great number of closely allied and highly variable species which have their head-quarters in the Mediterranean subregion; and while some groups of animals (as many Mollusca) may remain almost unchanged for entire geological periods, yet others, which, like the species of *Zygæna*, are specifically unstable, may become modified very rapidly. But, notwithstanding the large amount of specialty in the Algerian insect-fauna, it is essentially the same as the European, and the African element is exceedingly small. (There are some species of insects confined to South Spain and South Russia. These are probably very ancient forms, and may even be relics of the preglacial Palæarctic insect-fauna.) The large mammals of Algeria are apparently nearly all of African origin, having crossed from the south after the Glacial Epoch, and subsequently to the disappearance of the Saharan sea, and to the final separation of Europe and Africa, although some identical species of wide range penetrated into, or perhaps returned to Europe through Asia Minor, such, for instance, as the lion.

The Ethiopian Region, or Africa, is at the present day chiefly remarkable for the great number of large mammalia which inhabit it. Many of these, though formerly abundant in Europe and India, have long disappeared from both countries; and Africa has now a highly specialized character of its own. The Malagasy subregion, including Madagascar and the adjacent islands, is peculiarly remarkable, and "appears to indicate a very ancient connection with the southern portion of Africa, before the apes, ungulates, and felines had entered it"

(Wallace, "Geogr. Distr." i. p. 273). The insects of Madagascar, however, are closely allied to existing African species, and many of the most remarkable, formerly supposed to be peculiar to the island, have since been received from Natal or Zanzibar. There is also a considerable resemblance between the Mascarene fauna, and that of distant parts of the world, in which connection we may refer to the numerous traditions, previously mentioned, of recent subsidences in various parts of the Indian Ocean.

As a rule, competition is far more severe on continents than on islands; hence the great number of peculiar forms which survive in islands, though long superseded on continents, and it appears that according to this principle, the insects of Madagascar have become less strongly modified than those of the African Continent, and therefore represent to some extent a more ancient fauna. A remarkable case is afforded by two pairs of butterflies, inhabiting different parts of the world. One is *Papilis Merope*, a large black and white butterfly, with tails on the hind wings, found all over Tropical Africa, and varying considerably in different localities. The females are altogether unlike the male, being without a tail, and of a totally different shape and colour, resembling butterflies of other groups, which are protected from birds, &c., by their nauseous odour. But *P. Merope* is represented in Madagascar by *P. Meriones*, the female of which only differs from the male in the presence of an additional black bar on the fore wings. The other example is that of *Argynnis Niphe*, a common Indian species, which is tawny, with black spots, and the female of which has the tips of the forewings broadly dusky, with a black bar across them, giving it a great resemblance to *Danaus Chrysippus*, a widely distributed insect, which is "mimicked" in the same way by the females of several other butterflies besides *A. Niphe*, even including one of the female varieties of *Papilio Merope*, already referred to. But the Australian representative of *A. Niphe* (*A. inconstans*), though differing so little from the male of *A. Niphe* that it was long considered to be no more than a slight local variety, has the sexes alike, the female having no white bar on the wings, although a small *Danaus* (*D. Petilia*), closely allied to *D. Chrysippus*, is also found in Australia.

Turning to the Oriental Region, we find that North India is much richer in species than the south. This is partly owing to the greater variety of elevation (just as the southern peninsulas of Europe are poorer in species than the districts in which the central ranges lie*), but not entirely, since many North Indian

* Andalusia scarcely produces more species of butterflies than Sweden; Austria, Switzerland, or South France have nearly twice as many.

species, not found in South India, reappear in the Malayan peninsula and islands. The spread of Indian forms into Europe has been much checked by the position of the mountain ranges. Where these are more open, as along the coast of China and Japan, we find Indian forms extending much further north, and mingling with those which really belong to the Palæarctic Region.

One of the most striking features in the Australian Region in recent times was the abundance of large wingless birds, now mostly extinct. Traditions, more or less authentic, relating to the great birds of the remote islands, are common in Oriental writers, who referred to them under the names of Rukh, Seemurgh, Anka, &c. The rukh was said by Middle Age writers to be found in Madagascar (doubtless referring to the *Æpyornis* or its egg); but the Arabian writers always give the rukh the habits of an eagle or a vulture. The Arabs, we know, extended their voyages at least as far as Madagascar and the Aru Islands, and there is no improbability in their having also visited New Zealand, where I believe that remains of a gigantic bird of prey have recently been met with. The Arabs, of course, were well acquainted with the ostrich, now the largest living bird; hence, nothing but the great extinct birds could have given rise to the stories of the rukh. The Persians, less acquainted with these distant countries than the Arabs, made a mythological bird of the Seemurgh, but there is little incredible in the Arabian accounts of the rukh, except its gigantic size. The Greek or German Griffin may have had a similar origin.*

The Neotropical Region presents a great contrast to Africa, the other southern continent, for instead of a preponderance of large mammalia, we have here an enormous abundance of some of the smaller forms of life; in some groups, as, for instance butterflies, more than half of all the known species come from Tropical America.

The Nearctic Region, though somewhat poor in special forms as compared with the Palæarctic, to which its affinities are so close that it could scarcely be separated as a distinct region, if we confined ourselves to isolated groups, yet possesses as many large mammalia as South America. The fauna of both North and South America was formerly much richer than at present; but the Glacial Period was as destructive in North America as in Europe. What caused the destruction of the large mammalia

* The Rukh, or Roc, as in our old translation of the "Arabian Nights," is only alluded to, so far as we remember, in connection with its egg; the egg was probably that of *Æpyornis*, and the bird manufactured to suit it.—ED.

in South America is less certainly known; but Africa is now the only region which is sufficiently rich in the higher forms of life to lead us to suppose that it in any degree adequately represents the zoology of former times; and it appears to have been exposed in a less degree than other countries to the agencies which have destroyed animal life to so great an extent elsewhere.

In concluding this somewhat desultory article, we may remark that, contrary to the general idea, extreme heat seems to have a tendency to reduce the size of animals. The largest known animals are, or were, natives of cold countries; and most insects common to Europe or Japan, and India, are considerably smaller in the latter country. Even the tropical representatives of widely distributed genera are nearly always inferior in size and beauty to temperate forms.

ON ICE-MAKING AND ICE-MACHINES.

By W. N. HARTLEY, F.R.S.E.

THE resolution of all forms of energy into heat, the continual passage of heat through solids, liquids, and gases, and its tendency to become equally distributed through all matter, are now recognized as facts; hence the inevitable conclusion that finally all substances in the solar system, if not in the universe, will ultimately arrive at one common temperature. Mechanical motion, electricity, chemical action, all other forms of energy which at present are sources of heat, will be completely exhausted. Man, by his use of machines, is hastening this end of all things, and this indeed by the production of low as well as of high temperatures.

An economical means of freezing water is a fruitful source of profit at the present time, for the manufacture of ice serves not only the purpose of enhancing our bodily comfort in summer, but also for rapidly cooling large volumes of liquid, as in the operation of brewing and other industrial processes, and for the better preservation of animal food in seasons and climates which hasten putrefactive changes.

The difficulty experienced in freezing water is due to the very large amount of heat it must lose, firstly, in being lowered to the temperature of 32° F., and secondly in being changed from liquid water at 32° F. to solid ice at the same temperature. The first quantity is called its specific heat, and the second is its latent heat. These quantities are greater for water than for any other substance, hence the cooling power of ice is greater for any given temperature than that of any other body, and the cooling power of water is greater than that of any gas or liquid. Faraday calculated that the heat absorbed during the conversion of a cube of solid ice measuring three feet in the length of one side, into liquid water without undergoing any rise of temperature, would require the combustion of a bushel of coals for its artificial production.

It is evident from these statements that, in order to cool a

quantity of heated air or water down to a moderate temperature, a large supply of water is the best medium, not only on account of its abundance and cheapness, but because of its great capacity for heat.

When any elastic fluid is compressed, it becomes hot, and if it then be cooled down to its original temperature and be expanded, it is rendered as many degrees colder by its rarefaction as it was heated by its condensation; hence we have here a means of producing low temperatures. On the one hand we can ignite tinder by the heat evolved in the compression of air in a glass cylinder; and by the exhaustion of air in a bell jar the temperature may be reduced so that the moisture it contains is deposited as a mist. By the extremely rapid expansion of a liquefied gas when pressure is removed, or of a volatile liquid when its evaporation is hastened by mechanical means, we obtain the most effective cooling powers. The familiar experiment of freezing water or mercury in a red-hot dish is effected by the enormous expansion of liquefied sulphurous acid or of solidified carbonic acid, which substances regain the heat they lost when undergoing the change of liquefaction or solidification.

The production of intense cold by the rapid evaporation of ether projected in the form of a fine spray is a process which has been introduced with success into surgery by Dr. Richardson, for the purpose of producing a local insensibility to the pain caused by a knife or other instrument.

By enclosing ether in an air-tight vessel, and drawing off the vapour as fast as it is generated, evaporation is greatly accelerated, while the ether may be condensed again for further use. The original apparatus of Harrison, which depended upon this principle, consisted of a multitubular boiler immersed in an uncongealable liquid such as brine; an exhaust pump carried off the ether vapour which is rapidly formed at the expense of the warmth of the salt water. The reduction of temperature may reach 24° F., or what is commonly called 8° of frost. The ether was condensed by passing through a worm tube surrounded by a stream of cold water, and the chilled brine was made to circulate round metallic vessels containing the water to be converted into ice.

Many improvements have been made on this ether machine, and one of the most complete methods of working is now in operation on a large scale on the premises of the Manchester Patent Ice Company.

Messrs. Sidely and Mackay, of Liverpool, are the patentees of the apparatus, the chief characteristics of which are its adaptability to the satisfying of large demands, its economical use of the cooling power of the ether vapour, and its capability of making ice in thick blocks. Not only are exhaust pumps used

for evaporating the ether in the refrigerator, but pressure is exerted to liquefy the ether in the condenser. Both refrigerator and condenser are tubular vessels. Now, as the vapour passes from the refrigerator to be condensed by the pump, it is made to part with some of its chilliness either to ether going to the refrigerator, or to water about to be frozen; and again in its return passage to the refrigerator it is deprived of any oil which it may have acquired from the machinery. The whole of the cooling apparatus is below ground, and contained for the most part in pits of cement or asphalte. The water to be frozen is run into metallic tanks, between the inner and outer surfaces of which chilled brine at a temperature of 15° F., or 17° below freezing point, is made to circulate, the metallic vessels being connected by stout vulcanized india-rubber tubing. The water during freezing is kept in constant agitation, with two objects—first, to remove air, and so obtain clear ice; and second, to equalize the temperature throughout, so as to prevent the water freezing on the surface, as it ordinarily does on a pond. The ice is formed first round the sides of the cell, and gradually thickens till it closes up in the centre. The clearness of the ice is greatly increased by slow freezing, and to obtain this desirable condition the time allowed is from 60 to 90 hours. Each block of ice measures 3½ feet broad by 4 feet long, and is 13 inches in thickness; the weight varies from six to seven hundredweight. A simple contrivance to facilitate the removal of the ice by a crane travelling on rails laid on beams overhead, is a loop of rope which is frozen into each block. The ease with which, when placed on the ground, these large blocks can be slid about by the men is very advantageous. In order to loosen the ice from the cells, brine at any temperature above 32° F. is made to circulate in place of the frigorific liquid, and so greatly are the metallic vessels cooled that it requires a period of about an hour to loosen one of the blocks.

The magnitude of the operations is such that the engines can be worked up to 100-horse power, and are capable of turning out 30 tons of ice per day. On the occasion of a recent visit to this interesting factory there were 180 tons of ice in store, and some of the blocks were five weeks old. We have an apparent paradox in the fact that the combustion of one ton of coal in the furnace fires will produce eight tons of ice.

In the last number * of the Popular Science Review it was found necessary to refer to the researches of Faraday and others on the liquefaction of gases, and of Professor Andrews on the continuity of the liquid and gaseous states of matter; it is therefore of great interest to note how a purely scientific fact

* See "Mineral Cavities and their Contents."

can in a most unexpected way be made available for industrial purposes. No one could have imagined that the liquefaction of gases could prove of any practical benefit to mankind, but we now know that such is the case, since M. Carré's ammonia freezing machine depends upon the liquefaction of the gas by pressure, and its subsequent condensation in water after it has produced a low temperature by its evaporation. The operation is conducted without the application of any mechanical power. A hollow conical condenser of iron has a space between its inner and outer surfaces, which is connected by a tube with a boiler containing ordinary liquid ammonia; that is to say, a solution of about 700 volumes of ammoniacal gas in 1 volume of water. The conical condenser is immersed in a stream of cold water, while the boiler is heated over a fire or large gas-burner to a temperature of 270° F. During this operation the ammoniacal gas is expelled from the water, and is condensed by the pressure of its own particles and the cooling action of the stream of water. If now fresh cold water be placed in the condenser cone, and the heated boiler be cooled in water, the ammonia distils off at the expense of the heat in the water to be frozen, and finds its way back once more to the boiler, ready for another operation.

Leslie's famous experiment of causing water to be frozen by the rapid absorption of heat caused by its own evaporation has been modified by M. Carré, in such a manner that ice in small quantities, as, for instance, in water-bottles, may be made in a few minutes. The apparatus consists of an air-pump, to which the water-bottle is attached. As the handle of the pump is worked and the air exhausted, a quantity of oil of vitriol is agitated in a vessel, through which all aqueous vapour and air from the water-bottle must be drawn. The avidity with which the oil of vitriol absorbs the vapour as fast as it is formed so hastens the evaporation that in a few minutes a bottle of ice is the result.

Perhaps of all machines the one of most interest is that invented by M. Raoul Pictet, of Geneva, the striking feature in which is the employment of liquefied sulphurous acid as the absorbent of heat instead of ether. In all other machines there is a liability to a slight leakage, on account of the fact that the cylinder of the exhausting and condensing pump is kept airtight to some extent by the lubricating material. Now as ether and all kinds of grease are solvents of each other, it is easy to account for a certain amount of escape, which will be difficult to avoid. Liquefied sulphurous acid does not dissolve to any considerable extent in oil, and when free from moisture is without action on metals; and although it might be expected that the packing of the piston might in time be

acted on by sulphurous acid, yet this danger has been entirely obviated by the use of manufactured asbestos packing, which is now being greatly used for high-pressure steam-engines.

When required to work in hot climates, the ice-making machines most generally in use are open to serious objections, and grave inconveniences are experienced in their constant employment. Thus ammoniacal machines work at a pressure of twenty atmospheres, with water at 80° F., and are thus liable to leakage, or even to the danger of an explosion. Methylated ether-machines are open to the same objection, in addition to which there is a danger of fire when a leakage occurs, which unfits them for use at sea.

Now, in the use of sulphurous acid there is the great advantage that at 80° F. its tension does not exceed four atmospheres, while it may be liquefied at 25°, and its tension then is only equal to the pressure of the atmosphere. It has no action upon metals when kept free from water; and in order to obtain it in a perfectly anhydrous condition, M. Pictet prepares it by the action of heat on a mixture of oil of vitriol and sulphur, the gas being dried by oil of vitriol. The condensing and refrigerating apparatus consists of tubular vessels similar to those employed with other liquids, such as ether.

One of these machines is daily at work at the Chelsea Ice Rink, and is capable of making 40 tons of ice per day. The skating-floor, which is the invention of Mr. John Gamgee, consists of a number of flattened metallic tubes placed side by side on a bed of concrete or asphalte; the interior of the tubes is kept filled with an uncongealable mixture of glycerine and water, which is allowed to flow in from an elevated cistern. Clear ice is secured by coating the tubes with water spray, allowing this to freeze, and then sprinkling again. During last winter, tubes of thin sheet-iron were laid on the floating bath on the Thames, at Charing Cross, and a skating-floor was frozen. The temperature of an ice-rink from its agreeable coolness has an exhilarating and bracing influence, which dissipates the languor felt in a warm moist atmosphere.

M. Pictet's machine has interest beyond that of any ordinary economical producer of ice, for, constructed as it is with all the philosophical thought and scientific knowledge which we usually find bestowed only on instruments of research, it has been applied by its inventor to the purpose of establishing certain simple relations between the latent heat, molecular weights, and tensions of the vapours of volatile liquids.

By the application of mathematical reasoning and the use of known data, M. Pictet calculates the latent heat of various liquids, and arrives at the following conclusions:—

1. Cohesion is a constant quantity for all liquids.

2. The derivate of the Napierian logarithm representing the ratio between vapour-tension and temperature, is constant for all liquids, when they are compared under the same circumstances of pressure and temperature.

3. The latent heat of all liquids referred to one and the same pressure, multiplied by the molecular weight referred to a uniform temperature, gives a constant product.

4. For all liquids, the difference between the latent heat at any two temperatures, multiplied by the molecular weight, is a constant number.

5. The latent heat of every liquid is a multiple of its specific heat.

It would be entering too much into detail to give the method by which these very important conclusions have been arrived at, but it may be of interest to some readers to know that an article on the subject was published by M. Pictet in the last volume of the "Philosophical Magazine."

ON VORTEX MOTION.

BY PROFESSOR OSBORNE REYNOLDS,
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IN commencing this discourse the author said, Whatever interest or significance the facts of vortex motion may have, is in no small degree owing to their having, as it were, eluded the close mathematical search which has been made for them, and to their having in the end been discovered in a simple, not to say commonplace, manner. In the Royal Institution it is the custom to set forth the latest triumphs of mind over matter, the secrets last wrested from nature by gigantic efforts of reason, imagination, and the most skilful manipulation. For once, however, it would seem that the case is reversed, and that the triumph rests with nature, in having for so long concealed what has been so eagerly sought, and what is at last found to have been so thinly covered.

The various motions which may be caused in a homogeneous fluid like water, present one of the most tempting fields for mathematical research. For not only are the conditions of the simplest, but the student or philosopher has on all hands the object of his research, which, whether in the form of the Atlantic waves or of the eddies in his teacup, constantly claims his attention. And, besides this, the exigencies of our existence render a knowledge of these motions of the greatest value to us in overcoming the limitations to which our actions are otherwise subject.

Accordingly we find that the study of fluid motion formed one of the very earliest branches of philosophy, and has ever since held its place, no subject having occupied the attention of mathematicians more closely. The results have been, in one sense, very successful; most important methods of reasoning have been developed—mathematical methods, which have helped to reveal numberless truths in other departments of science, and have taught us many things about fluids which most certainly

* A lecture delivered at the Royal Institution, February 2, 1877, and printed here by permission of the author.

we should not otherwise have found out, and of which we may some day find the application. But as regards the direct object in view, the revelation of the actual motion of fluids, the research has completely failed. And now that generations of mathematicians have passed away, now that the mysteries of the motions of the heavenly bodies, of the earth itself, and almost of every piece of solid matter on the earth have been explained by mathematicians, the simplest problems of fluid motion are yet unsolved.

If we draw a disc flatwise through the water, we know by a process of unconscious geometrical reasoning that the water must move round the disc; but by no known mathematical process could the motion be ascertained from the laws of motion. If we draw the plate obliquely through the water we experience a greater pressure on the one side than on the other. Now this case, representing as it does the principle of action of the screw-propeller, is of the very highest importance to us; and yet, great as has been the research, it has revealed no law by which we may in a given case calculate the resistance to be obtained, or indeed tell from elementary principles in what way the water moves to let the plate pass. Again, the determination of the resistance which solid bodies, such as ships, encounter is of such exceeding economic importance, that theory, as shipbuilders call it, having failed to inform them what to expect, efforts have been, and are still being, made to ascertain the laws by direct experiment. Instances might be multiplied, but one other must suffice. If we send a puff of fluid into other fluid we know that it will travel to a considerable distance, but the manner in which it will travel and the motion it will cause in the surrounding fluid, mathematics have not revealed to us.

Now the reasons why mathematicians have been thus baffled by the internal motions of fluids appear to be very simple. Of the internal motions of water or air we can see nothing. On drawing the disc through the water there is no evidence of the water being in motion at all, so that those who have tried to explain these results have had no clue; they have had not only to determine the degree and direction of the motion, but also its character.

But although the want of a clue to the character of the motion may explain why so little has been done, it is not so easy to understand how it is that no attempts were made to obtain such a clue. It would seem that a certain pride in mathematics has prevented those engaged in these investigations from availing themselves of methods which might reflect on the infallibility of reason.

Suggestions as to the means have been plentiful. In other cases where it has been necessary to trace a particular portion

of matter in its wanderings amongst other exactly similar portions, ways have been found to do it. It may be argued that the influences which determine the path of a particular portion of water are slight, subtle, and uncertain, but not so much so as those which determine the path of a sheep. And yet thousands of sheep belonging to different owners have been from time immemorial turned loose on the mountains, and although it probably never occurred to anyone to reason out the paths of his particular sheep, they have been easily identified by the aid of a little colour. And that the same plan might be pursued with fluids, every column of smoke has been evidence.

But these hints appear to have been entirely neglected, and it was left for Nature herself, when, as it were, fully satisfied with having maintained her secret so long, and tired of throwing out hints which were not taken, at last to divulge the secret completely in the beautiful phenomenon of the smoke ring. At last; for the smoke ring is probably a phenomenon of modern times. The curls of smoke, as they ascend in an open space, present to the eye a hopeless entanglement; and although, when we know what to look for, we can see as it were imperfect rings in almost every smoke cloud, it is rarely that anything sufficiently definite is formed to attract attention, or suggest anything more important than an accidental curl. The accidental rings, when they are formed in a systematic manner, come either from the mouth of a gun, the puff of a steam-engine, or the mouth of a smoker, none of which circumstances existed in ancient times.

Although, however, mathematicians can in no sense be said to have discovered the smoke ring, or the form of motion which it reveals, they were undoubtedly the first to invest it with importance. Had not Professor Helmholtz some twenty years ago called attention to the smoke ring by the beautiful mathematical explanation which he gave of its motion, it would in all probability still be regarded as a casual phenomenon, chiefly interesting from its beauty and rarity. Following close on Helmholtz came Sir William Thomson, who invested these rings with a transcendental interest by his suggestion that they are the type after which the molecules of solid matter are constituted. The next thing to enhance the interest which these rings excited, was Professor Tait's simple and perfect method * of pro-

* The apparatus consists of a cubical box like a tea-chest, with a circular hole, six or eight inches in diameter, in its bottom, and a cloth loosely nailed over the top in place of a lid. The box is set on its end. The fumes of hydrochloric acid and ammonia are separately introduced into the box, when they combine and form a dense smoke, which is ejected from the orifice by patting the cloth. It appears that a somewhat similar form of apparatus was used by Faraday, and has long been known as a toy.—O. R.

ducing them at will, and thus rendering them subjects for lecture-room experiments. Considering that this method will probably play a great part in perfecting our notions of fluid motion, it is an interesting question how Professor Tait came to hit upon it. There is only one of the accidental sources of these rings which bears even a faint resemblance to this box, and that is the mouth of a smoker as he produces these rings. This might have suggested the box to Professor Tait. But since this supposition involves the assumption that Professor Tait sometimes indulges in a bad habit, and as we all know that Professor Tait is an eminent mathematician, perhaps we ought rather to suppose that he was led to his discovery by some occult process of reasoning which his modesty has hitherto kept him from propounding.

But however this may be, his discovery was a most important one, and by its means the study of the actual motion of these rings has been carried far beyond what would otherwise have been possible.

But it has been for their own sake, and for such light as they might throw on the constitution of matter, that these rings were studied. The most important lesson which they were capable of teaching still remained unlearned. It does not appear to have occurred to anyone that they were evidence of a general form of fluid motion, or that the means by which these had been revealed, would reveal other forms of motion.

There was, however, at least one exception, which will not be forgotten in this room: the use of smoke to show the effect of sound upon jets of air.

Also, the late Mr. Henry Deacon, in 1871, showed that minute vortex rings might be produced in water by projecting a drop of coloured water from a small tube. And his experiments, in spite of their small scale, excited considerable interest.

Four years ago, being engaged in investigating the action of the screw-propeller, and being very much struck by the difference between some of the results he obtained and what he had been led to expect, the author made use of colour to try and explain the anomalies, when he found that the vortex played a part in fluid motion which he had never dreamt of; that, in fact, it was the key to almost all the problems of internal fluid motion. That these results were equally new to those who had considered the subject much more deeply than he had, did not occur to him until after some conversation with Mr. Froude and Sir William Thomson.

Having noticed that the action of the screw-propeller was greatly affected when air was allowed to descend to the blades, he was trying what influence air would have on the action of a simple oblique vane, when a very singular phenomenon presented

itself. The air, instead of rising in bubbles to the surface, ranged itself in two long horizontal columns behind the vane. There was evidence of rotational motion about these air lines. It was evident, in fact, that they were the central lines of two systematic eddies.

That there should be eddies was not surprising, but eddies had always been looked upon as necessary evils which beset fluid motion as sources of disturbance, whereas here they appeared to be the very means of systematic motion.

Here then was the explanation of the nature of the motion caused by the oblique vane, a cylindrical band of vortices continually produced at the front of the plate, and falling away behind it in an oblique direction.

The recognition of the vortex action caused behind the oblique vane, suggested that there might be similar vortices behind a disc moving flatwise through the water, such as are the eddies caused by a teaspoon.

There was one consideration, however, which at first seemed to render this improbable. It was obvious that the resistance of the oblique vane was caused in producing the vortices at its forward part; so that if a vortex were formed behind a flat plate, as this vortex would remain permanently behind, and not have to be continually elongated, the resistance should diminish after the plate was once set in motion; whereas experience appeared to show that this was by no means the case. It appeared probable, therefore, that from some disturbing cause the vortex would not form, or would only form imperfectly, behind the plate.

This view was strengthened when, on trying the resistance of a flat plate, it did not appear to diminish after the plate had been started.

Accidentally, however, it was found that if the float to which the plate was attached was started suddenly and then released, the float and plate would move on apparently without any resistance. And more than this, for if the float were suddenly arrested and released, it would take up its motion again, showing that it was the water behind that was carrying it on.

There was evidence therefore of a vortex behind the disc. In the hope of rendering this motion visible, coloured water was injected in the neighbourhood of the disc, and then a beautiful vortex-ring, exactly resembling the smoke ring, was seen to form behind the disc. If the float were released in time, this ring would carry the disc on with it; but if the speed of the disc were maintained uniform, the ring gradually dropped behind and broke up. Here then was another part played by the vortex previously undreamt of.

That the vortex takes a systematic part in almost every form

of fluid motion was now evident. Any irregular solid moving through the water must from its angles send off lines of vortices such as those behind the oblique vane. As we move about we must be continually causing vortex rings and vortex bands in the air. Most of these will probably be irregular, and resemble more the curls in a smoke cloud than systematic rings. But from our mouths as we talk we must produce numberless rings.

One way in which rings are produced in perhaps as great numbers as from our mouths is by drops falling into the sea. If we colour the surface of a glass vessel full of water, and then let drops fall into it, rings are produced, which descend sometimes as much as two or three feet.

But the most striking rings are those produced in water, in a manner similar to that in which the smoke rings are produced, using coloured water instead of smoky air.

These rings are much more definite than smoke rings, and although they cannot move with higher velocities, since that of the smoke ring is unlimited, the speed at which they move is much more surprising.

In the air we are accustomed to see objects in rapid motion, and so far as our own notions are concerned, we are unaware of any resistance; but it is quite otherwise in water. Every swimmer knows what resistance water offers to his motions, so that when we see these rings flash through the water we cannot but be surprised. Yet a still more striking spectacle may be shown, if, instead of coloured water, a few bubbles of air be injected into the box from which the puff is sent; a beautiful ring of air is seen to shoot along through the water, showing, like the lines of air behind the oblique vane, little or no tendency to rise to the surface.

Such is the ease with which these vortex rings in water move, and so slight is the disturbance which they cause in the water behind them, as to lead to the conclusion that they experience no resistance whatever, except perhaps a little caused by slight irregularities in their construction. Their velocity gradually diminishes; but this would appear to be accounted for by their growth in size, for they are thus continually taking up fresh water into their constitution, with which they have to share their velocity. Careful experiments have confirmed this view. It is found that the force of the blow they will strike is nearly independent of the distance of the object struck from the orifice.

The discovery of the ring behind the disc afforded the opportunity of observing the characteristics of these rings much better than was afforded by the smoke rings; and also suggested facts which had previously been overlooked. The manner of

motion of the water which formed the ring and of the surrounding water was very clearly seen. It was at once seen that the visible ring, whether of coloured water or air, was merely the central line of the vortex; that it was surrounded by a mass of moving water, bearing somewhat the same proportion to the visible ring as a ball made by wrapping string (in and out) round a curtain ring until the aperture was entirely filled up. The disc, when it was there, formed the front of this ball or spheroid of water, but the rest of the surface of the ball had nothing to separate it from the surrounding water but its own integrity. Yet when the motion was very steady the surface of the ball was definite, and the entire moving mass might be rendered visible by colour. The water within the ball was everywhere gyrating round the central ring, as if the coils of string were each spinning round the curtain ring as an axis, the water moving forwards through the interior of the ring and backwards round the outside, the velocity of gyration gradually diminishing as the distance from the central ring is increased.

The way in which the water moves to let the ball pass can also be seen, either by streaking the water with colour or suspending small balls in it. In moving to get out of the way and let the ball of water pass, the surrounding water partakes as it were of the gyrating motion of the water within the *ball*, the particles moving in a horse-shoe fashion, so that at the actual surface of the *ball* the motion of the water outside is identical with that within, and there is no rubbing at the surface, and consequently no friction.

The maintenance of the shape of the moving mass of water against the unequal pressure of the surrounding water as it is pushed out of the way is what renders the internal gyratory motion essential to a mass of fluid moving through a fluid. The centrifugal force of this gyratory motion is what balances the excess of pressure of the surrounding water in the front and rear of the ball, compared with what it is at the sides.

It is impossible to have a ring in which the gyratory motion is great, and the velocity of progression slow. As the one motion dies out so does the other; and any attempt to accelerate the velocity of the ring by urging forward the disc, invariably destroyed it.

The striking ease with which the vortex ring, or the disc with the vortex ring behind it, moves through the water, naturally raised the question as to why a solid should experience resistance. Could it be that there was something in the particular spheroidal shape of these balls of water which allowed them to move freely? To try this, a solid of the same shape as the fluid ball was constructed and floated after the same manner as the disc. But when this was set in motion, it stopped directly—it

would not move at all. What was the cause of this resistance? Here were two objects of the same shape and weight, the one of which moved freely through the water, and the other experienced very great resistance? The only difference was in the nature of the surface. As already explained, there is no friction at the surface of the water, whereas there must be friction between the water and the solid. But it could be easily shown that the resistance of the solid is much greater than what is accounted for by its surface friction or skin resistance. The only other respect in which these two surfaces differ is that the one is flexible, while the other is rigid, and this seems to be the cause of the difference in resistance.

If ribbons be attached to the edge of the disc, these ribbons will envelope the ball of water which follows it, presenting a surface which may be much greater than that of the solid; and yet this, being a flexible surface, the resistance of the disc with the vortex behind it is not very much greater than it would be without the ribbons—nothing to be compared to that of the solid.

Colouring the water behind the solid shows, that instead of passing through the water without disturbing it, there is very great disturbance in its wake. An interesting question is as to whether this disturbance originates with the motion of the solid, or only after the solid is in motion. This is settled by colouring the water immediately in front of the solid before it is started. Then on starting it the colour is seen to spread out in a film entirely over the surface of the solid, at first without the least disturbance, but this follows almost immediately.

Among the most striking features of the vortex rings, is their apparent elasticity. When disturbed they not only recover their shape, but vibrate about their mean position like an elastic solid. So much so, as to lead Sir William Thomson to the idea that the elasticity of solid matter must be due to its being composed of vortex rings.

But apart from such considerations, this vibration is interesting as showing that the only form of ring which can progress steadily is the circular. Two parallel bands, such as those which follow the oblique vane, could progress if they were infinitely long, but if not, they must be continually destroyed from the ends. Those which follow the oblique vane are continually dying out at one end, and being formed again at the other.

If an oval ring be formed behind an oval plate, the more sharply curved parts travel faster than the flatter parts; and hence, unless the plate be removed, the ring breaks up. It is possible, however, to withdraw the plate, so as to leave the oval ring, which proceeds wriggling along, each portion moving in a direction perpendicular to that in which it is curved, and with

a velocity proportional to the sharpness of the curvature. So that not only does the ring continually change its shape, but one part is continually falling behind, and then overtaking the other.

These are some of the forms of fluid motion which imagination or reason had failed to show us, but which have been revealed by the simple process of colouring the water.

Now that we can see what we are about, mathematics can be most usefully applied; and it is expected that when these facts come to be considered by those best able to do so, the theory of fluid motion will be placed on the same footing as the other branches of applied mechanics.

REVIEWS.

FIELD GEOLOGY.*

OF the many elementary treatises and text-books prepared for the geological student, scarcely any treat of the method of observation in the field, or if so, only in a very general way. The "How to Observe," by De la Beche, and the "Guide du Géologue-Voyageur," by A. Boué, contain many valuable suggestions bearing on the subject, and may still be consulted with advantage. A good practical work has been long a desideratum, and this is to a great extent supplied by the "Field Geology" of Mr. Penning.

What to observe, how to observe, and how to record observations in the field, are important parts of geological study; and all theoretical knowledge derived from hand-books by the student of geology, should if possible be supplemented, as in the medical curriculum, by clinical instruction and observation at the bedside. For one of the real objects of inquiry in the field is to understand, when examining a section in a quarry or a sea-cliff, the nature of the various beds, and the conditions under which they were accumulated. In these respects the chapters on Lithology and Palæontology (chaps. iii. and iv.) will be of service, although the latter chapter might be corrected and improved; a dry list of fossils, without a knowledge of their bearings, being of little use.

The chapters devoted to geological mapping and sections form an important part of the book, as these are essential elements in understanding the structure of a country. The operations and the means of carrying them out are clearly given by the author, and are accompanied by tables and plans which render the text clearer, especially as regards the drawing of boundary lines, a practical matter of considerable importance, instruction in which has been somewhat neglected.

With this view the author first describes the necessary instruments used in field-surveying, and then proceeds in a very systematic and detailed manner to show their applications, and the methods by which the tracing of geological boundaries is effected and the construction of horizontal sections carried out; as well as how errors may arise in the latter case if the

* "Field Geology." By W. H. Penning, F.G.S.; with a section on Palæontology, by A. J. Jukes-Browne, B.A., F.G.S. Sm. 8vo. London: Baillière, Tindall, & Cox. (No date.)

surface of the ground along the line of such section is not accurately represented.

The last two chapters contain (1) the practical application of geological surveying, involving the methods and operations described in the preceding pages, and (2) the way in which geological knowledge and reasoning may be turned to account with regard to the supply of water and the origin and character of soils.

The book is a useful addition to geological literature, and no earnest student of the science should fail to consult it, and carry out in the field the instructions contained in its pages, which the author has rendered as concise as possible, in order to facilitate the acquirement of a knowledge of field geology, and to embody in a small compass practical directions and suggestions which are to be found only here and there in more important works.

THE GERM-THEORY OF DISEASE.*

THE author of this very ingenious book explains contagion and the course of fevers by the theory of special germs being introduced from without into the body. "The theory is, that many diseases are due to the presence and propagation in the system of animal organisms having no part or share in its normal economy. This it is, and no more. It is essential to be clear on this point; for the opponents of the germ-theory, and, to some extent, its advocates also, have introduced into the discussion of that theory the questions of the source and mode of origin of these organisms—a complication which has tended to hamper men's minds and to divert attention from the real subject of discussion—*the competence of germs to produce the phenomena of disease.*" The morbific agent propagated in and given off from the bodies of the sick—a *contagium*—may gain entrance into other bodies through the lungs or the alimentary mucous surface. This is an organic body too small to be seen except through the agency of the electric beam, and which propagates in the blood and acts as a parasite. The shiver of fever is produced by a sudden and enormous development of the germs, and the non-elimination of urea to their demanding nitrogen. Just as micrococci are visible in the tissues affected by diphtheria, so these infinitely small germs do equivalent mischief. We must hope for some new treatment which will settle these germs, and until that is discovered we must be in the same condition as we were in our beliefs thirty years ago, when Southwood Smith decided that fever was from want of oxygen, and because salt made the fever-blood red and arterial-looking, salted, and sometimes cured his patients. As a matter of fact, did not Sir Henry Holland elaborate the germ-theory thirty years ago?

The book is well worth reading, and is sufficiently free from professional technicalities, so that it may be read by the public with advantage.

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* "The Germ-Theory Applied to the Explanation of the Phenomena of Disease. The Specific Fevers." By T. Maclagan, M.D. 8vo, London: Macmillan. 1877.

FOSSIL CRUSTACEA.*

PERHAPS no more striking example of the usefulness of the process of taking stock in scientific matters could very well be adduced than the "Catalogue of British Fossil Crustacea" just prepared by Mr. Henry Woodward, and published by the Trustees of the British Museum. Little more than twenty years ago, when Professor Morris brought out the second edition of his admirable "Catalogue of British Fossils," he recorded only 306 species of crustaceans. The advance in this department of palæontology has since been so great that Mr. Woodward can now number no fewer than 979 distinct species, besides 72 named varieties. The number has thus been considerably more than trebled in twenty years, and when we remember that for the most part the additions have been made sporadically, that is to say, by scattered descriptions and notices in a great number of books and papers, it will easily be seen that Mr. Woodward has a strong claim upon the gratitude of all students of palæontology for the labour he has undergone in producing his present work. And this labour is by no means small; the catalogue contains not only a classified enumeration of the known British crustacean fossils, with particulars of the formations and localities in which they occur, but also a full synonymy of both genera and species. Mr. Woodward is so well known as a careful and conscientious student of the fossil remains of this class of animals, that it is almost unnecessary to say that his work is thoroughly well done, and will prove a most valuable aid to all future investigators.

The study of the fossil crustacea presents many points of high interest. They are, as Mr. Woodward well indicates, among the very oldest of undoubted organic remains. Leaving the Laurentian *Eozoon* out of the question, as still of somewhat uncertain nature, the Lower Cambrian deposits of the St. David's district of South Wales have furnished various geologists, and especially Mr. Henry Hicks, with a series of fossils among which crustaceans occupy the very first rank, not only as regards their number when compared with the fossil organisms of other groups, but also as presenting a complexity of organization which would seem to indicate that even at that remote period of the earth's history they must have had already a long series of predecessors. Trilobites, some of them of large size and very complex structure, can hardly be regarded as representing the earliest realization even of the crustacean type: and their occurrence so low down in the series of stratified rocks may serve as an encouragement to geologists to search elsewhere in deposits of still greater antiquity for traces of the dawn of life.

Starting from this point the crustacea go on through the whole series of fossiliferous deposits, acquiring a greater and greater variety of form and organization as they advance towards the present day. Of the thirteen orders into which Mr. Woodward divides the class, only two have become

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* "A Catalogue of British Fossil Crustacea, with their synonyms and the range in time of each genus and order." By Henry Woodward, F.R.S., F.G.S. 8vo. Printed by order of the Trustees of the British Museum. London, 1877.

extinct, namely, the Trilobita and the Eurypterida, which are confined to the Palæozoic formations; of three other orders, the Cladocera, the Copepoda, and the singular parasitic Rhizocephala, no fossil representatives are known; but from the Jurassic epoch onwards, all the rest of the orders appear to be more or less abundantly represented. Of the parasitic forms, some of which are among the most interesting of existing crustacea, one can scarcely expect any traces to be preserved, but even of these there are indications of the existence of one species of *Bopyrus*, parasitic under the carapace of a crab, in the Cambridge Green-sand. Of several other groups, the number of known fossil representatives is but small when compared with the abundance of forms living at the present day, and in some cases this can hardly be due to the easy destructibility of the animals, which is undoubtedly the cause of the disappearance of the parasites. Many hitherto unknown forms belonging to these groups will probably reward the labours of zealous searchers among the rocks; and to all who may endeavour to fill up the gaps in our knowledge, either by the discovery of new forms or by making us better acquainted with the structure and characters of those numerous species which are still but imperfectly known, Mr. Woodward's catalogue will be an invaluable boon.

THE STEAM ENGINE.*

THOSE who wish to understand the theory and action of the steam-engine, but can bring to bear upon the subject scarcely more mathematics than ordinary arithmetic, will no doubt be grateful to Mr. Northcott for the trouble he has taken to simplify the subject. After a slender sketch of the history of the engine, he discusses briefly such questions as the formation of coal, the origin of force, and the nature of combustion. As to the thermal values of different forms of fuel, their behaviour in the furnace, and the best conditions for transferring heat from the furnace to the boiler, these are subjects so important to everyone who uses a steam-engine that we are glad to see them discussed with some fulness. The reader must not expect to find in this work a description of the constructive details of the various forms of steam-engine, but nevertheless the author describes the action of the mechanism, and compares the various forms of engine with respect to their efficiency. Several indicator-diagrams are given, and explained at some length. The work also contains some useful tables, which have evidently cost the author much labour in their compilation. To render the subject intelligible to the practical engineer was Mr. Northcott's principal object, but at the same time he has aimed at securing precision. Anyone who does not feel equal to facing such works as those of Rankine may dip with profit into Mr. Northcott's volume.

* "The Theory and Action of the Steam Engine, for Practical Men." By W. H. Northcott, C.E., &c. 8vo. London: Cassell, Petter & Galpin.

MEASURING MACHINES.*

IT is hardly too much to say that the power of producing true surfaces lies at the bottom of all machine construction. When Watt first constructed his steam-engine one of his great difficulties consisted in making the piston fit true to the cylinder. Such extreme precision has, however, since been obtained that we are now able to detect the difference of fit in two pistons though they may not differ by more than the ten-thousandth of an inch in diameter. This great advance in the construction of machinery of precision is due mainly to the exertions and ingenuity of Sir Joseph Whitworth, who has spared no pains to effect improvements in this direction. His steel "surface-plates" are indeed the nearest approach to absolutely true planes which human ingenuity has yet contrived. So true, in fact, are these surfaces that if a piece of gold-leaf be rubbed between them it entirely disappears, its molecules being forced into the pores of the steel. Sir Joseph's standard gauges are likewise marvels of mechanical skill. Professors Goodeve and Shelley have therefore rendered no small service to students of mechanics by putting before them clear descriptions of these instruments of precision, but above all by describing the beautiful measuring machine with which the name of Whitworth will always be associated.

There are two ways in which minute linear magnitudes may be gauged; one being the old method of measurement by means of the micrometer and microscope; the other being the method of "end measurement," which relies upon truth of surface and delicacy of touch. The latter is the principle on which the Whitworth machine is based. At first sight it may seem strange that minute differences of magnitude should be more readily detected by the sense of feeling than by the eye aided by the microscope. Yet Sir J. Whitworth has shown beyond doubt that this is the case. Workmen in securing a good mechanical fit usually depend on touch, and the "feeling piece" attached to the Whitworth machine can be manipulated with extreme delicacy.

It must be remembered that Sir Joseph's measuring machine is not intended so much for measuring the actual length of a bar as for determining very minute differences in the lengths of specially prepared bars: hence it is peculiarly adapted for multiplying copies of standards of length. For use in the workshop a Whitworth machine is constructed to indicate a difference of one ten-thousandth of an inch; but the great triumph is the far more delicate instrument by which a difference of a millionth of an inch may be detected. To understand the construction of this beautiful instrument the reader must refer to the series of plates attached to the work of Professors Goodeve and Shelley.

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* The Whitworth Measuring Machine, including Descriptions of the Surface Plates, Gauges, and other Measuring Instruments made by Sir Joseph Whitworth, Bart., &c. By T. M. Goodeve, M.A., &c., and C. P. B. Shelley, C.E., &c. With four plates and 44 woodcuts. 8vo. London: Longmans. 1877.

AMERICAN PUBLICATIONS.

AMERICAN publications which we must regard as more or less national in their character continue to reach us with astonishing voluminousness, leading us to admire more and more the liberality of the Governments of the United States.

Foremost among them we must notice the Bulletin* of that wonderful institution the "Geological and Geographical Survey of the Territories" which, under the guidance of its chief, Dr. F. V. Hayden, has done so much good work in making known the structure and productions of those far-western regions which not many years ago formed almost a *terra incognita*. Of this most admirable repertory we have received the second and third numbers of Vol. III., the first having unfortunately not reached us. Number 2, a stout part of 340 pages, is exclusively devoted to the description of the species of certain groups of Arthropoda, collected during the surveying expeditions into the Western Territories. It contains a long paper on "Western Diptera," by Baron Osten Sacken; a report by Dr. P. R. Uhler on the insects collected by him in 1875, with descriptions of Hemiptera collected by Dr. Packard; and descriptions of spiders from Colorado, by M. T. Thorell. In the second of these papers Dr. Uhler introduces a sort of monographic treatment of two families of Hemiptera, the Cydnidæ and the Saldidæ, which will be of much use to students, but here and in other parts of his paper we regret to see what appears to be a reckless multiplication of generic groups. It must be confessed, indeed, that Dr. Uhler has a sufficient number of companions to keep him in countenance in his iniquities, but we cannot but feel that the true comprehension of the relations of organisms will be rather retarded than forwarded by the analytical process which is carried on by nearly all the zoologists of our day, the accepted notion being apparently that wherever a slight difference can be indicated a generic name must be imposed. M. Thorell's paper relates solely to the true spiders of the Colorado district, of which he describes a good many new species.

The contents of Number 3 are of a more miscellaneous nature. The ethnologist will find a comparative vocabulary of the dialects of the Indians of Utah, which is followed by a short note on the methods of making stone weapons, illustrated with a plate. Dr. A. C. Peale notices some peculiar eruptive "igneous and yet non-volcanic" mountain masses in Colorado, on which he hangs certain considerations as to the geological history of the district. Professor Cope contributes a report on the Judith River formation and on vertebrate fossils obtained by him from it and from other deposits on and near the Missouri, in which he describes many reptilian remains; whilst Dr. C. A. White describes the *Uniones* and other freshwater mollusca collected by Professor Cope, and also some from the tertiaries of Wyoming and Utah, gives a catalogue of the known invertebrate fossils from the fresh and brackish water deposits of Western North America, compares the North

* Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iii. Nos. 2 and 3. 8vo. Washington. 1877.

American Mesozoic and Cænozoic Unionidæ and associated mollusca with living species, and discusses the palæontology of the same formations in the Green River region.

The zoological papers are not numerous, but what there are are of considerable interest. Dr. Elliott Coues contributes some notes on the North American forms of insectivorous mammals, which appear to be preliminary to a complete monograph of the group, the North American species of which, although not numerous and belonging to only two families, have already been the subjects of considerable diversity of opinion. Mr. C. A. H. McCauley's notes on the ornithology of the region about the source of the Red River of Texas, which are annotated by Dr. Elliott Coues, are also an important contribution. Besides furnishing a list of the bird-inhabitants of an out-of-the-way locality, they give a good deal of information upon the habits of the species observed. A catalogue of the land and freshwater shells of Nebraska by Dr. Aughey, a formidable list for a single State, and a report by Mr. A. D. Wilson on the geographical work of the Survey, conclude the 3rd number of this Bulletin for 1877.

Another publication under the auspices of the Survey of the Territories is the Bulletin of the Entomological Commission,* two parts of which have reached us. Both these pamphlets are devoted to the consideration of that terrible scourge of the western farmer, the Rocky-Mountain locust (*Caloptenus spretus*) whose ravages appear to be extending further and further east with each succeeding year. The second part contains an admirable account of the natural history of this pest, illustrated with a map showing the extent of country infested by it; the first part deals solely with the methods to be adopted for destroying the young, or, as our American cousins with their usual fondness for idiomatic expressions prefer to call them, "unfledged" locusts. The Entomological Commission consists of MM. Riley, Packard, and C. Thomas.

Other Government publications that we have received, are Professor Newcomb's "Investigation of Corrections to Hansen's Tables of the Moon," forming Part 3 of papers published by the U. S. Transit of Venus Commission, an investigation undertaken for the purpose of enabling the longitudes of the observation-stations to be accurately determined; and the volume of Astronomical and Meteorological Observations for 1874,† published in the present year. The last-named volume carries its own description with it; but we may notice that besides the ordinary tables of the results of observations, it contains an appendix giving a most interesting description of the astronomical instruments in the Observatory (one of them being a magnificent 26-inch equatorial), illustrated with heliotype representations of the different instruments, and also a second appendix on the difference of longitude between Washington and Ogden, Utah.

The Seventh Annual Report of the Massachusetts State Board of Health,‡

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* Bulletin of the United States Entomological Commission. Parts 1 & 2. 8vo. Washington. 1877.

† "Astronomical and Meteorological Observations made during the year 1874 at the United States Naval Observatory." Rear-Admiral C. H. Davis, Superintendent. 4to. Washington. 1877.

‡ "Seventh Annual Report of the State Board of Health of Massachusetts. January, 1876." 8vo. Boston. 1876.

is a stout volume of 550 pages, with numerous plates and folding maps and plans. The most important portion of its contents consists of reports on the pollution of rivers and the disposal of sewage, questions which are already forcing themselves on the inhabitants of the older States almost as unpleasantly as upon ourselves. These reports are very elaborate, and many comparisons are made with the state of things prevailing on this side of the water. Some sanitary hints, and especially a treatise on defects in house-drainage by Mr. E. S. Philbrick, are also of interest.

We have still to notice the publications of the Smithsonian Institution, which, as usual, are of great value. The Report for 1875,* the last that has reached us, contains as usual an elaborate statement of the doings of this most admirable body, with an appendix in which, besides several translations and reprints, we find some original memoirs of considerable importance, chiefly on anthropological subjects. Mr. H. Gillman has a curious paper on "Certain Characteristics pertaining to Ancient Man in Michigan," in which he records the very frequent occurrence of perforated humeri in the mounds on the Detroit and Rouge rivers, this peculiar formation being met with in about 50 per cent. of the number found. It is remarkable as being associated with platycnemism. Mr. Gillman also describes and figures several examples of artificially perforated skulls from the mounds of the same region. A very long and elaborate paper, by Dr. C. C. Abbott, treats of the remains of the stone age in New Jersey, and is illustrated by upwards of 200 figures of stone implements, advancing from rudely-chipped forms to those of more careful construction, ground and even engraved. The objects include some tobacco-pipes of stone, and pottery of various patterns.

Two parts of the Smithsonian Contributions,† published in 1876, also go back over this antiquarian ground, which, although as compared with the archæology of the old world, it may be in part comparatively modern, is certainly to a considerable extent prehistoric so far as America is concerned. Dr. Joseph Jones gives a most interesting account of his explorations of the aboriginal remains of Tennessee, the burial caves, stone-graves, mounds and earthworks, and the numerous objects obtained from them. Many of the latter are very curious and interesting. Dr. Jones finds that the crania of the stone-grave and mound-building race of Tennessee belong to the Toltecan division of American nations, agreeing markedly with those of the Inca Peruvians and the Toltecs of Mexico. They have usually been altered by pressure. Many of these crania also bear a striking resemblance to those of the Natchez, and hence Dr. Jones infers that the aborigines of Tennessee were probably descended from the Toltecs, and related to the Natchez, and endeavours from an examination of historical documents relating to the early knowledge of this part of America, to ascertain what may have been the history of these extinct people. He notes that the mode of burial in stone coffins or cists adopted by them

* "Annual Report of the Board of Regents of the Smithsonian Institution, for the year 1875." 8vo. Washington. 1876.

† "Smithsonian Contributions to Knowledge." Nos. 259 and 267. 4to. Washington. 1876.

differs from that practised by any other North American tribe; further, they were idolaters, and the physiognomy of many of their idols more or less resembles that of some of the Toltec idols. Both the headdresses and physiognomy of some of the idols are suggestive of an Eastern or Chinese origin. Their connection with Central America and the Gulf of Mexico is indicated by the presence of numerous large sea-shells in the mounds, by the representation of Central American birds and animals on their pipes and culinary vessels, and by their making use of obsidian, fluor-spar, and serpentine for constructive purposes.

The description of the "Archæological Collection of the United States National Museum," by Mr. Charles Rau, which forms the second part of the Smithsonian Contributions for 1876, is a most important contribution to the knowledge of American archæology. Implements, weapons, and ornaments, articles of stone, clay, metal, wood, shell, bone, and horn, are most carefully described and profusely illustrated, so that the book will form an excellent treatise of reference for all future students.

ELEMENTARY PHYSICS.*

NO branch of science is more popular than that which we used to call Natural Philosophy, and which most people now-a-days call Physics. Nor is this to be wondered at. For the forces of nature, though unseen themselves, are constantly manifest in their effects upon the world of matter around us; and a person endowed with ordinary curiosity must needs be anxious to learn something about such phenomena as those of gravitation, heat, light, and electricity. For imparting a sound knowledge of physics, we can hardly point to any better elementary work than the well-known Treatise of Deschanel, which has been much improved by Professor Everett in the English translation. But this beautifully-illustrated work is perhaps a little too elaborate for the beginner, and hence the translator and publisher have thought fit to bring out an introductory text-book, dealing with similar subjects. The result is the excellent little work now in our hands. What should, and what should not, be introduced into such a work is, of course, in large measure a matter of individual opinion; but Professor Everett, as a teacher of long experience, has in most cases exercised great judgment in the selection of his materials. The wisdom of his discretion is seen in the way in which he avoids details, whilst dwelling on general principles; not cramming the beginner with a multitude of facts, but rather teaching him to connect a few great facts together. It need hardly be said that the most modern views are everywhere introduced, and that Professor Everett has taken an early opportunity of employing the modern C. G. S. system of units; that is to say, the Centimetre, the Gramme, and the Second are taken as the units respectively of length, mass, and time. A *Dyne* is the new name for the *unit of force*; a dyne is therefore that force which, acting upon a mass

* "Elementary Text-book of Physics." By J. D. Everett, M.A., D.C.L. F.R.S.E., &c. Sm. 8vo. London: Blackie & Son. 1877.

of one gramme, produces a velocity of one centimetre per second. Again, the term *Erg* is used to denote the *unit of work*, or the work done by a force of one dyne acting through a distance of one centimetre. Before leaving the volume, it should be remarked that each section is accompanied by a set of well-chosen problems. Altogether the work is admirably adapted to the wants of teachers who really desire to give their students a solid groundwork in the principles of physical science.

PHYSICS OF THE ETHER.*

IN this work an attack is made with considerable energy on two giants, which unfortunately are but straw-stuffed—the allied theories, as the author calls them, of "action at a distance" and "potential energy." As a mere matter of fact, scientific men do not even use the words "action at a distance" as the title of any theory; and what they understand as "potential energy" is not by any means what our author supposes. Newton's gravity, which our author supposes to be an example of force assumed to act at a distance, "without the intervention of material or physical agency," was not so understood by Newton himself, who may be presumed to have known what he meant by it. He distinctly pronounced the idea inconceivable, that a body can act on another, or through a vacuum, without the intervention of anything else by or through which the force may be conveyed from one to another. Towards the close of his "Principia," he says: "We have explained the phenomena of the heavens, and of our sea, by the power of gravity, but have not yet assigned the cause of the power." And then, after showing what may certainly be inferred respecting gravity, he proceeds, "I have not hitherto been able to discover the cause of these properties of gravity from phenomena, and I frame no hypotheses." One hypothesis only did he actually consider, the hypothesis namely of action at a distance, but only to reject it, as one which no one could for a moment entertain "who has in philosophical matters a competent faculty of thinking." So, too, of electricity. Our author is quite mistaken in supposing that it is regarded by men of science as acting at a distance in his sense of the words. Nor again are either gravity or electricity supposed to act with infinite rapidity. Mr. Preston says, "if we take the case of an electro-magnet and a piece of iron, then, when the electro-magnet is suddenly put in the magnetic condition by the electric current, it is assumed in accordance with the theory of action at a distance that the agency by which the distant piece of iron is put in motion requires no time to pass from the magnet to the iron." Nothing of the sort is assumed. No reference is made to the time required in this case, any more than in speaking of a luminous object at a short distance we mention the time which the light requires to travel from it to the eye, for the time is practically evanescent; but it is no more regarded as absolutely evanescent in the case of magnetic

* "Physics of the Ether" By S. Tolver Preston. 8vo. London: E. & F. N. Spon. 1875.

attraction than in the case of light, where it is known certainly not to be evanescent. All we assert of gravity is that its action certainly travels with a velocity enormously exceeding that of light. This is known from phenomena. What its velocity is we have no means of determining, simply because the motions of the heavenly bodies show as yet no signs of the finiteness of the velocity with which the action of gravity is transmitted. This velocity is therefore practically infinite, that is, it is infinite in the same sense in which the velocity of light is infinite in ordinary terrestrial observations.

"Potential energy" is an expression really belonging to modern science; but it is not what Mr. Preston supposes. It *is* in one sense a form of energy depending on position, precisely as the tension of an elastic string connecting two bodies depends on the position of the bodies; but it can no more be said to depend on position only than can the tension of such a string. We do not know what it actually depends on besides position, for we do not know how gravity is caused; and we do know what the tension of the string depends on, for we can see and examine the string. That is the chief distinction between the two cases. No man of science, no one in fact "with a competent faculty of thinking," has ever supposed that in one case more than in the other *mere* difference of position was a form of energy.

It will be manifest from what we have said about Mr. Preston's work, that whatever value his own ideas respecting the ether may have, his corrections of the views he supposes to be accepted by men of science have no value whatever. He says "the present work is the result of much thought and careful study." He may have given much *thought* to it, but can scarcely have studied his subject very carefully. It is hardly to be expected that in a matter of such transcendent difficulty as he has selected for the subject of reflection, much can be accomplished without the most thorough investigation of at least all the verified phenomena, and no slight study of the researches and thoughts of the leading men of science who have dealt with the matter. We have seen how very little Mr. Preston appears to know about the theories of men of science. As to observed phenomena, his knowledge is very unequal. In some cases the facts he depends upon are correctly stated, in others they are doubtful, in others they are absolutely incorrect. As an instance of the last-named kind, we find at p. 130 the statement that the rate of transmission of electricity in materials of the greatest diversity is appreciably uniform—a circumstance which electricians will be a good deal surprised to learn.

We have given more space to Mr. Preston's work than its intrinsic value merits, because the erroneous ideas which he entertains respecting the accepted views of science about gravity, electricity, potential energy, and so forth, are very common. It is worth while to indicate, even at some expenditure of space, the views really entertained by men of science on this subject.

VIS INERTIÆ IN AIR AND OCEAN.*

MR. JORDAN'S last two works afford melancholy evidence of the fatuity of paradoxism. In volume vii. we had occasion, now some nine years since, to discuss his *Vis Inertiæ*, "a book nicely bound, well printed on good paper, abounding in maps, diagrams, and charts, yet—what Sterne would have called hobby-horsical." Nine years have not sufficed to show him how utterly without foundation is his system of the world, for like every true paradoxist, he proposes to run his hobby-horse full tilt at the centre of all things; and in the later of the two works now in our hands, announces his "System of the World," price one guinea. The basis of his system is easily explained. The solid earth turning on its axis from west to east leaves the water somewhat behind, which therefore has a relative motion towards the west. Hence the great equatorial currents. The air is left still more in the lurch, and thus has a westerly motion, even relatively to the water. Hence the trade winds. The planets nearest the sun are in like manner left behind in consequence of *vis inertiæ*. Hence they do not complete a circuit in the same time as the sun rotates. The remoter planets are left behind in greater degree, and hence the planetary periods grow longer and longer as the distances from the sun increase.

A reviewer unfamiliar with the ways of paradoxists might hope to indicate the error underlying this reasoning. For instance, he might hope to explain that even supposing that a solid earth could be set rotating within a fluid envelope at rest, this, which would at first lag, must eventually acquire the rotational movement in full degree, since otherwise an infinite effect would accrue from a finite cause; viz., never-ceasing friction from the original rotational impulse. And again, he might hope to show that what Mr. Jordan calls astral gravitation could not affect the fluid envelope without affecting in equal degree the solid mass within. Assuming him to possess the benevolence of a De Morgan, a reviewer might endeavour, even without hope, to explain a few of the elementary laws of physics to Mr. Jordan. We possess, however, neither hope to set a paradoxist right, nor infinite benevolence. Mr. Jordan's answer to any attempt to show that he does not rightly understand the laws of physics would simply be, as in his preface to "The Winds," "I rightly apprehend the fundamental principles of physics to be wrong." One point only do we care to controvert. He represents himself as in controversy with Dr. Carpenter and Professor Huxley respecting his theory of *vis inertiæ*. It is barely conceivable that a paper of Mr. Jordan's, read before the Geographical Society, was there and then replied to by Huxley. But we do not believe that there has been any subsequent controversy with Mr. Jordan; and we are quite certain that any discussion of his theory would be the most complete waste of time. No amount of reasoning would convince Mr. Jordan of its absurdity; nor can we conceive it possible that any besides himself has the least faith in it.

* "The Winds and their Story of the World," and "Remarks on the recent Oceanic Explorations and the current-creating action of *vis inertiæ* in the Ocean." Both by W. L. Jordan, F.R.G.S. 8vo. London: Hardwicke and Bogue. 1877.

Certainly, if there are any such, reasoning would be thrown away upon them, What *they* would need would be to study the elementary laws of physics with care and patience for a few years, after which no reasoning would be wanted. But no one acquainted with the ways of paradoxists would think of recommending such a course to Mr. Jordan himself.

PHYSIOLOGICAL ÆSTHETICS.*

THE object of this work is to "elucidate physiologically the nature of our æsthetic feelings," to relegate the emotional to a purely physical origin, and to explain our conceptions of beauty relatively to pleasurable and painful feelings—the natural result of the action of an organism which is "a highly complex, but not absolutely perfect self-regulating machine"—"possessing the mysterious attributes of consciousness." The author, a man of much culture, writing in an admirable style, dedicates his book to "the greatest of living philosophers, Herbert Spencer" (by permission). Influenced by the tone and fashion of his master, Mr. Allen, a most enthusiastic disciple, fortunately writes clearly and nervously, and is often good enough to place the somewhat involved language of the great philosopher in plain and comprehensible English. He looks upon Herbert Spencer as Tait regards Sir William Thomson, and like him adds polish and facility of style to his "great one." Well instructed in the dominant physiology of the day, perfectly *au fait* with the modern development of the theory of the conservation of energy, and no mean student of art, the author has produced a book which is most readable and instructive; and doubtless as entertaining to the school to which he belongs as it is exasperating to those who think that there is inspiration in art and in the idea of beauty. As Herbert Spencer believes that in the progressing course of human modification under natural selection, sin will cease to be—so it follows from Mr. Allen that as years roll on, and a kind of art-pangenesis prevails and overcomes, the idea of the beautiful will become more fully evolved; and poetry, the drama, painting and sculpture will transcend modern description. Following up the same evolutionary notion, we must be impressed that ugly women will cease to be, and that by the time that the globe and the universe are to disappear in the Tyndallian azure, physical, moral, intellectual, and æsthetical perfection will have been arrived at. *Et puis?*

The author, wishing to examine the æsthetic feelings, and believing them to be intermediate between the bodily senses and the higher emotions, connects them with a physiological law of pleasure and pain. The feelings aroused in man by the beautiful in nature and human art are his subject matter, and he insists on their bearing a definite relation to pleasure and pain, and then of course to physical nervous change. Pain he decides to arise from severance, disruption, and disintegration of absolute nerve tissue; and pleasure to be "the concomitant of the healthy action of any or all of the organs or members supplied with different cerebro-spinal nerves *to an*

* "Physiological Æsthetics." By George Allen, B.A. 8vo. London: Henry S. King & Co. 1877.

extent not exceeding the ordinary powers of reparation possessed by the system." Of course it is stated that pleasure and pain are the reflex of the actual state of the nerves, and that painful sensations may in their earlier stages be pleasurable and *vice versa.* Moreover, natural selection involves that "whatever is prejudicial or beneficial to the organism as a whole, is generally painful or pleasurable respectively to the separate organs which it is likely to affect. The healthy nutrition of our organs, if not relieved by functional activity; (and the same may be said of the tissues and muscles), leads to a tendency to exercise the superabundant energy in "play;" and when "we similarly exercise our eyes or ears, the resulting pleasure is called an æsthetic feeling." So "the æsthetically beautiful is that which affords the maximum of stimulation with the minimum of fatigue and waste in processes not directly connected with the vital functions. The æsthetically ugly is that which conspicuously fails to do so, which gives little stimulation, or makes excessive and wasteful demands upon certain portions of the organs. But as in either case the emotional element is weak, it is mainly recognized only as an intellectual discrimination. And so we get the idea of the æsthetic feelings as something noble and elevated, because they are not distinctly traceable to any life-serving function." The author has a capital chapter on taste, which he sums up with a very pertinent joke: "While it is true that *de gustibus non est disputandum*, it is eminently untrue that 'there's no accounting for tastes.'" Æsthetic education and the total effect of the æsthetic environment on happiness, are treated ably, and then the author passes on to the consideration of the lower senses in the concrete—taste, smell, feeling—and then those of higher import are noticed—hearing and seeing. A chapter on mental pleasures and pains is followed by one on the simulative arts and poetry. In treating of the influence of rhythm and sound in the enjoyment of poetry, the author notices how Milton and Tennyson achieve much success in "metrical technique;" and he remarks upon the influence of a change of the constituent part of a fixed metre in asserting the idea of imitation in the poet's work, quoting Tennyson—

> "The long brook falling through the cloven ravine,
> In *cataract after cataract* to the sea."

The work concludes with a practical answer to the question which must have arisen in the mind of every reader of this work: "Where, it will be asked, in such a system is there room for genius? If poetry consists of such special combinations of such special elements, why cannot any man sit down and write a great poem?" The author gives an admirable reply.

MACHINE DESIGN.*

ARBITRARY rules for the construction of machines are to be picked up in the drawing-office of almost any mechanical engineer. A work on machine design might, indeed, be easily compiled by stringing together a

* "The Elements of Machine Design: an Introduction to the Principles which determine the Arrangement and Proportion of the Parts of Machines and a Collection of Rules for Machine Design." By W. Cawthorne Unwin B.Sc., &c. London: Longmans. 1877.

number of these empirical dicta, with just sufficient explanatory matter to secure cohesion. Professor Unwin, however, as might have been expected, takes a much more lofty view of his subject, and while giving a collection of rules needful in the workshop, spares no pains to expose the theoretical aspect of machine construction. Between the man who works by mere rule of thumb and the man who follows scientific principles, there is of course all the difference in the world. As long as the same type of machine is being constructed, the old rules serve their purpose well enough; but let new materials or new forms of construction be introduced, and the mere "practical man" finds himself immediately at sea. It surely needs no mean amount of scientific knowledge to determine how the parts of a complex machine should be duly proportioned, so as to best resist the action of forces acting both from within and from without. Machine design has indeed been raised to the rank of a science, mainly by Redtenbacher; and in the work before us Professor Unwin has given an excellent compendium of the science in its present state.

Evidence of labour conscientiously spent in the preparation of this work is unquestionably stamped upon its pages. While the author clearly explains the art of machine design, he takes care also to explain the principles on which the art is based; and as a necessary consequence of this treatment his pages bristle with formulæ. Yet they are not in any wise formidable, and will present no difficulty to a student of ordinary intelligence. Scientific men might, perhaps, wish to see the metrical system of units introduced, but the old system here employed recommends itself by being familiar in all workshops. The work forms one of Messrs. Longmans' series of "Text-Books of Science," and falls well within the original aim of the series—that of providing especially for the needs of candidates for Whitworth Scholarships.

THE AMATEUR MECHANIC.*

WORKING with a lathe is so popular an amusement that Mr. Hobson's little book will, no doubt, be welcome to many an amateur. It gives us, in very plain language, a good deal of information about lathes and lathe-tools, drilling and planing machines, vices and other appendages to the bench; and it even touches upon the subject of brass-founding. As we read how to do this or that bit of work, we feel that we are being taught by one who has really handled the tools, and takes enthusiastic interest in his subject. Anyone attending to Mr. Hobson's teaching ought certainly to be able to construct for himself a model of a steam-engine; and, what is more than can be said of all home-made engines, when constructed it would probably work.

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* "The Amateur Mechanic's Practical Hand-book, describing the different Tools required in the Workshop, the Uses of them, and how to Use them; also Examples of different kinds of Work, with full Descriptions and Drawings." By Arthur H. G. Hobson. London: Longmans. 1877.

SHORT NOTICES.

*Mushrooms and Toadstools.**—We have never yet known a student of fungi who did not try to persuade his acquaintances to eat the objects of his study; and Mr. Worthington Smith is no exception to the rule. As his little book has reached a third edition, we may hope that he has found numerous proselytes; and we can safely recommend it as a guide not only to intending agaricophagists, if such a term be admissible, but also to all wanderers in country places who wish to learn something about the curious plants of which it treats. Mr. Smith notices and figures twenty-nine common species of edible mushrooms, and thirty-one poisonous forms.

Window Gardening.†—Mr. Mollison has produced an exceedingly elegant little manual for the guidance of all who desire to adorn their rooms with growing plants. He describes the management of plants in pots, window-boxes, and hanging frames; the different constructions of these articles best adapted for various purposes, the arrangement and management of Wardian cases, and the more ambitious window conservatories; notices the best plants for cultivation under various circumstances, and even descends from the balcony to the area, and gives directions for its adornment in a style which ought to earn him the gratitude of those worthy people of whose flirtations it is popularly supposed to be the scene. The little work is illustrated with coloured plates and numerous woodcuts.

The Morse Alphabet.‡—"Ce n'est que le premier pas qui coûte" is the motto of the anonymous author of a very little pamphlet which proposes to teach anyone the Morse alphabet in half an hour. This first step, at any rate, only costs fourpence. The idea is to represent the dots and dashes of the Morse alphabet by the syllables of words, the initial letter of which shall be the one represented by the combination. Thus "against" represents the - —— which stands for A. The author has been rather hard put to it to find suitable words, and in several cases he has not been successful, as may be understood from the fact that he has been compelled to make syllables short or long according as their vowel is followed by one or two consonants, without regard to pronunciation.

The Carbon Process.§—It is said that Michael Angelo, in obedience to a

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* "Mushrooms and Toadstools: how to Distinguish easily the Differences between Edible and Poisonous Fungi." By Worthington G. Smith, F.L.S. Third Edition, small 8vo. London: Hardwicke & Bogue. 1876.

† "The new Practical Window Gardener; being Practical Directions for the Cultivation of Flowering and Foliage Plants in Windows and Glazed Cases, and the Arrangement of Plants and Flowers for the Embellishment of the Household." By John R. Mollison. Small 8vo. London: Groombridge & Sons. 1877.

‡ "How to Learn the Morse Alphabet in Half an Hour." By the Author of "International Communication by Means of Numbers." Small 8vo. London: E. Marlborough & Co. 1876.

§ "Die Kohle-Druck und dessen Anwendung beim Vergrösserungs-Verfahren, nebst einer Notiz über Photomikrographie." Von Dr. Paul E. Liesegang. Fünfte Auflage. Düsseldorf: Phot. Archiv. Berlin: T. Grieben.

capricious command of Pietro de Medici, was at one time compelled to mould a statue in snow. Art in perishable material is always a thing to sigh over, and even if a photograph be not in every sense a work of art, it is nevertheless painful to see the beautiful sun-pictures slowly fade away. Permanence is what the photographer long struggled after, and what he at last secured by the carbon process. Of all the chemical elements carbon is perhaps the most stable; and the ink with which these lines are printed, having carbon for its basis, is well-nigh imperishable. Various processes have been introduced to the photographer for printing his pictures in media containing carbon, the germ of these processes being found in the remarkable effect of solar light on bichromate of potash in solution of gelatine. All the practical details of carbon-printing are clearly given by Dr. Liesegang in the neat little work before us, which forms one of the "Bibliothek für Photographen." We find, of course, a description of the author's method of producing enlarged carbon prints from small negatives. The work also contains much information on the production of permanent photographs for the magic lantern from small objects viewed under the microscope. So much attention is now paid in Germany to the magic-lantern as a means of scientific instruction, that a journal entitled the "Laterna Magica," edited by Dr. Liesegang, is now regularly issued at Düsseldorf.

*Dr. Tyndall's Electricity.**—To administer doses of science to juveniles home for their Christmas holidays is a task more difficult and delicate than some people may be willing to concede. Dr. Tyndall, however, is singularly successful in this work, and always contrives with rare tact to gild the scientific pill. The lectures on electricity in the work before us are admirable examples of the way in which experimental science may be effectively presented to boys and girls. All the experiments are ingeniously devised and inexpensively carried out. In fact the special feature of the work consists in showing how the leading principles of statical electricity may be demonstrated with simple apparatus of very homely type. Apples, potatoes, eggs, straws, tin-foil, glass tumblers—such are the familiar objects with which the greater number of the experiments are performed. It is often objected that physical science cannot be taught in schools in consequence of the expense of apparatus. Whilst admitting that there is something in this objection, it certainly loses half its force on a perusal of these lectures. Indeed, almost everything used in the experiments here described may be had for a five-pound note. And surely no school could object to so small an outlay for a course of lectures on electricity.

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* "Lessons in Electricity at the Royal Institution, 1875-6." By John Tyndall, LL.D., D.C.L., F.R.S. London: Longmans. 1876.

SCIENTIFIC SUMMARY.

ASTRONOMY.

What are the Nebulæ?—A paper by Mr. Stone has recently been communicated to the Royal Society, in which he actually bases on Huggins's discovery of the bright line spectrum of certain nebulæ the theory that these are clusters of stars and not gaseous masses. His reasoning is remarkable. "The sun is known to be surrounded by a gaseous envelope of very considerable extent. Similar envelopes must surround the stars generally. Conceive a close stellar cluster. Each star, if isolated, would be surrounded by its own gaseous envelope. These gaseous envelopes might, in the case of a cluster, form over the whole, or a part of the cluster, a continuous mass of gas. So long as such a cluster was within a certain distance from us the light from the stellar masses would predominate over that of the gaseous envelopes. The spectrum would therefore be an ordinary stellar spectrum. Suppose such a cluster to be removed further and further from us; the light from each star would be diminished in the proportion of the inverse square of the distance; but such would not be the case with the light from the enveloping surface formed by the gaseous envelopes. The light from this envelope, received on a slit in the focus of an object-glass, would be sensibly constant, because the contributing area would be increased in the same proportion that the light from each part is diminished. The result would be that at some definite distance, and all greater distances, the preponderating light received from such a cluster would be derived from the gaseous envelopes and not from the isolated stellar masses. The spectrum of the cluster would therefore become a linear one, like that from the gaseous surroundings of our own sun." It seems hardly credible that a former first assistant at Greenwich and a mathematician of Mr. Stone's acknowledged power should reason in this wise. As shown in 1870, by Mr. Proctor, in a paper on resolvability as a test of distance ("Monthly Notices of the Roy. Astr. Soc." vol. xxx.), an irresolvable star-cluster would retain its intrinsic brightness unchanged, however its distance varied, so long as it continued irresolvable. For as the stars (separately undiscernible) became fainter with distance, the area over which they would be scattered would become smaller, and in the same degree. Dr. Huggins has thought it necessary to reply to Mr. Stone's paper! "Waiving the objections which may be urged against Mr. Stone's reasoning," he considers the results of observation. He points out (1) that there are not found in the spectra of different nebulæ the differences of relative brightness of the

bright lines and continuous spectrum, which would exist on Mr. Stone's hypothesis; (2) the star-clusters just within the resolving power of the largest telescopes do not give, even faintly, a spectrum of bright lines; and (3) the same bright lines appear to be common to all the nebulæ which give a bright-line spectrum, whereas on Mr. Stone's hypothesis, differences of constitution of the enclosing atmospheres of different star-groups would be probable. Towards the close of his reply, Dr. Huggins indicates the objection we have above enforced, and mentions that this objection was strongly insisted upon by Professor Stokes in remarks made when Mr. Stone's paper was read.

Supposition that Sunlight can be condensed.—Similar in incorrectness to the supposition that the brightness of an irresolvable stellar cluster can be diminished by distance, is the belief that under any circumstances sunlight (or other light from a luminous disc or surface) can be strengthened or condensed. It is singular that this mistake should have been fallen into by the present first assistant at Greenwich almost at the same time as the late first assistant enunciated the theory above discussed. A paper, too preposterous to be here dealt with, had been read before the Astronomical Society, suggesting that Venus has a metallic surface and a vitreous atmosphere. Referring to this paper, though of course rejecting the metallic surface and glass envelope, Mr. Christie pointed out that a mirror surface and an atmosphere capable of interior specular reflection, or the first alone with an ordinary refractive atmosphere, would explain the fact (?) that the arc of light seen round Venus in transit is brighter than the sun itself. Oddly enough a reply was made to this to the effect that a mirror surface was not needed for the purpose, but that ordinary refraction in the atmosphere of Venus would very much condense the sun's light, by compressing the whole disc of the sun into a fine arc of light around the outer limb of the planet. In point of fact, it is utterly impossible to condense light in this or any other way. As Mr. Proctor has shown, in a paper read before the June meeting of the Astronomical Society, by whatever process the breadth of the luminous surface is diminished (*i.e.* the axes of pencils proceeding from different parts of it brought nearer to parallelism), by the same process and to the same degree, the pencils themselves are made more divergent; thus a given portion of the retina receives pencils of light from a wider area of the sun's surface, but the quantity of light received from each pencil is in the same degree diminished. The arc of light seen round Venus was simply brighter than the neighbouring part of the sun's disc, because that light came from the whole of the sun, and the central part of the sun's disc is brighter than the part near the edge.

Distances of the Stars.—Mr. Stone, Astronomer-Royal at Cape Town, has gone over a portion of the evidence relative to the distribution of the fixed stars with respect to distance. It is singular that a matter so well-worn should still attract the attention of astronomers, more especially of official astronomers, whose duties in reality have no relation to such questions. "It may have been shown," says Mr. Stone, referring to Mr. Proctor's researches, "that some astronomers have attached undue importance to the numerical accuracy of the results obtained by W. Struve; but I cannot consider that the average distribution of stars according to apparent brightness has been,

or indeed ever will be, disproved. I do not know that there is much novelty in my views," &c. And then he proceeds to go over the old ground, very nearly along the old course, coming naturally to very nearly the same goal that W. Struve, Von Littrow, and others have reached. Mr. Stone's mathematical treatment of the portion of the evidence which he selects is of course perfectly sound; and if only that portion is considered, then unquestionably the conclusion at which he arrives must be regarded, not indeed as demonstrated, but as the conclusion which has in its favour the greatest weight of probability. But as there is a great deal of much weightier evidence, which he entirely omits to consider, and as that evidence is not merely opposed to the general conclusion at which Mr. Stone arrives, but demonstrates the incorrectness of that conclusion, the care and skill with which the imperfect evidence is dealt with, are in reality thrown away. Mr. Stone deals with the observed increase of numbers in stars down to Argeländer's ninth magnitude, comparing that increase with what would occur if stellar brightness depended in general on distance, stars being scattered with general uniformity throughout space; and he finds a general accordance between this theory and the observed facts, whence he deduces the conclusion that the theory is sound. But as it is certain that if the theory were sound there would be no real aggregations or rather segregations (in *space*) of stars of many orders of real magnitude, and as if there were no such aggregations there would certainly be no apparent aggregations of stars of many orders of apparent magnitude on the star-vault, it follows certainly that if such apparent aggregations exist, the theory of general uniformity of distribution is incorrect. It would not follow certainly, if no such aggregations existed, that the theory was sound, but it is certain that if they exist the theory is unsound. But it has been shown that they exist. They are made manifest to the eye in Mr. Proctor's equal-surface chart of 324,000 stars, where in some parts the stars are so closely set that there is barely room for them, minute though their discs are, while elsewhere they are strewn very sparsely—the regions rich in stars of the leading orders of apparent magnitude being those very portions of the Milky Way in which stars down to the twentieth magnitude are found in greatest numbers. The theory, then, of a general equality in the distribution of stars in space, even in the neighbouring parts of the system of stars, cannot be sound. As Mr. Proctor pointed out in a paper read at the May meeting of the Astronomical Society, if a surveyor were to urge against a theory respecting certain mounds that the mounds have in reality no existence, seeing that, if they were levelled, the general level of the ground would be very nearly the same as though the mounds had not been there—his arguments would not be thought to have much weight. Mr. Stone's theory (sound though its mathematical portion is) is of a similar kind. It is simply a demonstration of the fact that if we leave out of consideration the aggregations of stars on the star vault, these aggregations no longer afford any evidence of the real aggregation of stars in space.

Approaching Opposition of Mars.—Dr. Terby, of Louvain, who has devoted much attention to the subject of the charting of Mars, calls attention to the questions which he has raised in his memoir on the subject. These questions are quoted elsewhere in the present number. He begs astronomers to com-

municate their observations to him, to enable him to perfect Mr. Proctor's chart of the planet.

The Astronomer-Royal has also invited attention to observations in connection with the determination of the solar parallax, which might advantageously be made at the approaching opposition of Mars. He cited, from the "Monthly Notices" of 1857, his paper "On the means available for correcting our measures of the sun's distance during the next twenty-five years," in which, alluding to Flamsteed's method by observing the displacement of Mars in right ascension when he is far east and far west of the meridian, and pointing out its facilities, he had concluded that this method is the best of all. "An unexpected opportunity," he continued, "of obtaining observations, probably of a much superior class, has presented itself. Lord Lindsay is willing to lend his heliometer; and Mr. Gill, who has had extensive experience in the use of that instrument, and is perfectly acquainted with its adjustments of all kinds, offers his own time and labour at St. Helena or Ascension." He then referred to the probable expenses of the expedition. Since then, the sum necessary (500*l.*) has been granted by the Astronomical Society, one-half to be eventually repaid, either from the Government allowance to the Royal Society, or by Lord Lindsay and Messrs. De la Rue and Spottiswoode. The place since selected by Mr. Gill is the Island of Ascension, where the weather is likely to be more suitable than at the Mauritius. A rigid determination of the planet's heliocentric position will be among the objects of Mr. Gill's observations.

The Total Eclipse of the Moon last February.—Mr. Penrose remarks that during totality the northern and southern parts of the moon appeared very much brighter than the eastern and western parts; adding that this "presumably arose from some interference with the light refracted through the earth's atmosphere, from a greater prevalence of clouds in the equatorial regions than at the two poles; some amount of specular reflection, at very flat angles from the northern and southern ice, may also have aided in producing this effect." Mr. Penrose is so thorough a master of the geometry of eclipses, and so well able to calculate the amount of light falling upon various parts of the moon from the irregular ring of light which must appear to surround the earth as supposed to be seen during totality from the moon, that we cannot doubt the above sentence was penned without much thought; for it is certain that the light from various parts of that irregular ring is mingled and in nearly equal proportions over all parts of the moon's eclipsed hemisphere, not distributed locally. The mistake of attributing the different degrees of light on various parts of the eclipsed moon to this cause is as old as Wargentin, if not older. Probably Mr. Penrose had noted it in some of the older descriptions of eclipses without perceiving that it is erroneous; and naturally enough quoted it, without remembering that he had not closely examined it.

Rev. Fr. Perry remarks that the thin circle of light on the moon's limb was in such striking contrast with the cloudy dull brick-red shading of the centre that to many persons it seemed as if the moon was not completely immersed in the earth's shadow. Fr. Perry and Mr. Penrose formed, by the way, entirely different views respecting the definiteness of the umbra's outline. Fr. Perry says, "the darkness of that portion of the penumbra which

was in close proximity to the umbra was so great that the last contact was difficult to observe." Mr. Penrose found, however, that even simultaneous unaided eye-observations of the beginning and end of totality did not differ by many seconds.

Opposition of Ariadne.—The minor planet Ariadne (43) is in opposition on July 24, in circumstances very favourable for determining its diurnal parallax by the heliocentric method. The distance of the planet from the earth is 0·83, the sun's mean distance from the earth being taken as unity. Mr. Gill proposes to observe this planet with the heliometer during his stay at Ascension, where the observations will be made under very favourable conditions. Opposition will occur ten days before he can begin to observe Mars satisfactorily. The observations can therefore be made without inconvenience or additional expense. "It is true," says Mr. Gill, "the planet is somewhat faint (8·8 mag.), but experience at Mauritius has taught me that with such a heliometer as Lord Lindsay's, in a tropical sky, 8·5 mag. stars can be measured with more accuracy than any other, and that ninth mag. stars can be well measured in favourable atmospheric conditions. The geometrical conditions are very much more favourable than in the case of Juno (whose distance at opposition was 1·05); and besides it is possible to select more suitable stars of comparison . . . The opposition of Iris (7) and Melpomene (18) are also very favourable."

The Planet Vulcan.—It is hardly necessary to say that the transit of Vulcan, expected by Leverrier on March 22 (or 21 or 23), was not observed either in the northern or the southern hemisphere.

The Great Meteor of March 17 last.*—Captain Tupman has collected together various observations of this meteor, as seen at Frome, Cambridge, Kensington, Gunnersbury, Tetbury, Rossall, and Brighton. From these he has deduced the following inferences:—

The radiant must have been very near R.A. 145°, N.P.D. 95°, at an altitude of 35°. The meteor first became visible 60 miles over 50° 59′ N., 3° 4′ W. (or nearly over Taunton). The point of disappearance was about 39 miles above 5° 41′ N., 3° 4′ W. (near Pontypool). This path satisfies all the descriptions within ordinary errors of observation. The length of the path was about 59 statute miles. The duration was given as certainly about 3s., by Mr. Homer; 4s. or 5s., by Mr. Hollis; 3s., by Mr. Ballard, at Banbury; and 2s., by another observer. The mean of these is 3·1s., giving a relative velocity of 19 miles per second. From the radiant point given above the following parabolic elements of the orbit are deduced:—

Rising node	177·4
Inclination	8·5
Longitude of perihelion	222·5
Perihelion distance	0·850
Motion	*Direct.*

Whence the relative velocity is 33·3 statute miles per second, and the total duration 4½ seconds. It follows, then (though Captain Tupman makes no reference to the point), that, if the duration was rightly observed, the real path of the meteor was hyperbolic.

During the first half of its track the meteor was like burning magnesium

in appearance, then the colour became red, and lastly was vivid green. All along its track fiery ashes fell towards the earth, and after the extinction of the principal part, a body of dark-red sparks continued to fall for a short distance, as seen by Mr. Davis, at Tetbury. Lady Portsmouth, driving near Basingstoke, 90 miles from the meteor, and facing west, "was startled by what appeared to be blue or bluish-green lights falling apparently in large flakes into a field on her left. Some seconds after, while the whole country was lighted up as if by the brightest possible lightning, a large red ball was seen travelling with comparative slowness on the right over a field, into which it appeared to fall." From Waterford the meteor was seen to be double, one part closely following the other. This duplicity is not reported from any other place. The meteor left little or no streak, and did not detonate, for several of the observers state that they listened for any noise.

Captain Tupman mentions as a curious instance of inaccuracy that a certain person writing over the signature "J. M. W." in the "Times," describes the meteor "as two-thirds of the size of the moon *when overhead.*" At first this was supposed to mean that the meteor, when overhead, so appeared; and Captain Tupman noted that the meteor was never in reality within 65° of the zenith of London. But it was explained that "J. M. W." meant that the meteor was two-thirds of the size of the moon when she is overhead—a curious double error, seeing that the moon never is overhead in London, and that her size when at her highest is not different, so far as ordinary naked eye observation is concerned, from her size when near the horizon. But how can the general public be expected to be accurate when we find in a text-book of astronomy, by a well-known author, such blunders as the statement that the stars which pass overhead in London rise and set on a slant—the truth being that they never come within 13° of the horizon?

New Comets.—On April 6, Professor Winnecke, of the Imperial Observatory at Strasburg, announced the discovery of a new and rather bright comet. He soon after published the following elements, side by side with which we set Hind's later and doubtless more correct result:—

	WINNECKE.	HIND.
Perihelion Passage	April 18·1741 (Berlin Time)	April 17·64887 (G.M.T.)
Longitude of perihelion .	251° 59′ 57″	253° 30′ 9″
Ascending node . . .	317° 51′ 18″	316° 33′ 53″
Inclination . . .	56° 42′ 42″	58° 54′ 22′
Perihelion	0·92824	0·950250
Motion	Retrograde	Retrograde

Another new comet, much fainter, was discovered by M. Borelly, on the evening of April 14, in R.A. 16° 31′; N.P.D. 34° 56′; daily motion in R.A. + 120′, in N.P.D. − 50′.

Phenomena for the Quarter.—Jupiter, which was in opposition on June 19, will reach his second station on Aug. 20, and quadrature on Sept. 17. Mars will pass his first station on Aug. 17, perihelion on Aug. 21, and be in opposition on Sept. 5, midnight. Saturn will be in opposition on Sept. 9, two P.M. Neptune on quadrature on July 30, and stationary Aug. 10, will thence pass to opposition on Oct. 28.

BOTANY.

On the Trees and Shrubs of the South of France which Perish in Severe Winters.—M. C. Martins has communicated to the Academy of Sciences ("Comptes rendus," March 19, 1877, p. 534), a paper on the indigenous trees and shrubs of the South of France which suffer from frost in exceptionally severe winters, in which he attempts to demonstrate their relationship to the former flora of this part of France. These plants are as follows, arranged in the order of their sensibility to cold:—*Ceratonia siliqua, Euphorbia dendroides, Ostrya carpinifolia, Nerium Oleander, Chamærops humilis, Myrtus communis, Anthyllis barba-jovis, Laurus nobilis, Anagyris fœtida, Punica granatum, Olea europæa, Ficus carica, Coriaria myrtifolia, Smilax aspera, Pistachia lentiscus, Viburnum tinus, Quercus Ilex, Cistus monspeliensis,* and *Vitis vinifera.*

M. Martins remarks that these plants are all more or less of exotic types. Some of them are the sole European representatives of certain groups, families, tribes, or genera of plants. *Anthyllis barba-jovis, Pistachia lentiscus, Viburnum tinus, Quercus Ilex,* and *Cistus monspeliensis* alone form parts of families which possess other European genera or species. Most of them are of rare and local occurrence, only flourishing in exceptionally sheltered places, having the climate warmer, both in summer and winter, than open spots exposed to all winds. The *Pistachia*, the *Cistus*, the *Smilax*, and the Evergreen Oak are the only ones common throughout the Mediterranean littoral zone of France. *Vibernum tinus* and *Anagyris fœtida* flower in the middle of winter.

All these peculiarities M. Martins thinks may be easily explained by assuming that these plants are survivors from the flora which covered the soil of Southern France during the Tertiary period. The vegetation of that period, as revealed by its fossil remains, indicates a much warmer climate than now prevails in the littoral zone, and most of the species which scarcely differ from those now living are found in the lacustrine deposits of the region itself, and have been for the most part described by Count Saporta. Of *Ceratonia* five fossil species are described; one, the *Ceratonia siliqua*, has survived the climatic changes which have occurred since the Miocene, and especially the Glacial epoch. Its most probable ancestor is *C. vetusta*, Sap., from the gypsum of Aix. The common Myrtle is the descendant of *Myrtus atava*, Sap., of the Miocene calcareous slates of Armissan, near Narbonne, and it has been found fossil in the volcanic deposits of Saint-Jorge, in Madeira, by Professor Heer. The Oleander (*Nerium Oleander*) passed through the whole Tertiary period. It occurs in the Eocene of the Sarthe, and in the Miocene of Oropo, in Attica, and its form, *N. Gaudrianum*, Ad. Brongn., is intermediate between *N. Oleander* and *N. odorum*. Thus the fossil species has split into two living species. Thirty fossil species of Laurels are known; one, *Laurus nobilis*, is still living in the region, and it existed during the lower Pliocene epoch, as it occurs in the tufs of Meximieux. Nearly-allied species, *L. canariensis*, Webb, and *L. fœtens*, Ait. (*Oreodaphne fœtens*, Nees), descending from *Oreodaphne Heerii*, Gaud., of the Tuscan Quaternary deposits, have maintained themselves in the Canaries, the insular climate of

which approaches nearer than that of the South of France to the climate of the Tertiary periods.

In his memoir M. Martins shows, in like manner, that most of the tender trees and shrubs of the South of France have their fossil ancestors in Tertiary or Quaternary strata, formed at an epoch when the climate of Europe was so warm that many plants inhabited countries where they could not now pass a single winter. He instances the occurrence of *Chamærops humilis* in the north of Switzerland, of the Oleander in the Sarthe, of the Pomegranate in the neighbourhood of Lyons, and of the Vine in Silesia. This note of M. Martins' is an interesting contribution to the confirmation and extension of results already obtained by various palæontologists, especially Heer and Ettingshausen, as to the filiation of the existing flora to that of Tertiary times.

CHEMISTRY.

The Absorption-Spectrum of Potassium Permanganate, and Volumetric Analysis.—While concentrated solutions of this salt exhibit a broad absorption band which blots out all the green and a part of the blue of the spectrum, the same liquid, when rendered very dilute, is recognized in the spectroscope by the presence of five distinct and separate lines or bands, the first of which is near D, the last at F, and the middle one of all between E and *b*; the first and last are considerably less dark than the others. These bands are readily distinguished, even after often-repeated dilution, and the second and third of them, which are the last to disappear, can be perceived almost as long as the liquid itself shows a reddish tint. In the performance of volumetric analyses of colourless solutions the point where the fine colour of permanganate ceases to be destroyed is readily determined; if the liquid under examination, however, has a distinct colour which renders the reaction obscure to the eye, the exact stage when an excess of permanganate is added may be found by aid of the spectroscope. Brücke, who has devised this useful means of giving increased accuracy to several analytical processes in which permanganate is employed, makes use of a direct-vision spectroscope by Steinheil; he explains, moreover, in his paper, how observations can be made with a common prism of 60°. In the case where it is desired to determine quantitatively a comparatively small amount of iron protoxide in the presence of iron oxide, the degree to which the solution can be diluted is limited, lest the error of observation become too great. An excess of permanganate, however, may be added to the yellow solution, which shall so little affect the tint of the liquid that it cannot be distinguished from a simple concentrated solution of the higher oxide. An observation with the spectroscope will then indicate the presence of the characteristic absorption lines of the manganese salt, and solution of a salt of iron protoxide of known strength can then be added till they disappear; and thus the necessary correction can be made. It is pointed out by the author that this method, which can be employed with complete success by such persons as are colour-blind, may be made use of in the case of solutions of any degree of concentration or dilution. There is a method for the volumetric determina-

tion of iodine when in combination, proposed by Hempel and described by Mohr in his "Lehrbuch der Titrirmethode," which under certain conditions cannot be carried out with the desired precision, from the fact of the liberated iodine giving a violet tint to the liquid. Brücke shows how his method can be advantageously made use of in this case. If any salts of cobalt happen to be present in a solution in which the amount of a constituent is to be determined by means of permanganate, their pink colour so closely resembles that of the diluted reagent that the point when oxidation is effected is difficult to arrive at; the use of the spectroscope, however, enables the operator to detect the moment when the reaction is complete. A pale red solution of a cobalt salt was prepared, and a portion diluted with water; permanganate was then added to it till the tint closely resembled that of the other portion, except that the colour was very slightly more violet; when placed before the spectroscope the difference was very marked, all the five lines being readily seen. —*Journal für praktische Chemie*, lxxxviii., 486.

Neptunium.—During the last seventeen years the beautiful method of spectrum analysis has been the means of identifying five new elementary bodies: cæsium, rubidium, thallium, indium, and gallium. It is with no little interest that we find that the existence of another element, in this case also a metal, has been detected by the old and more difficult method of mineral analysis. Hermann, who published his first paper on minerals containing metals of the tantalum group a third of a century ago, has found a new metal, which he has named neptunium, in a specimem of "tantalite" from Haddam, in Connecticut. His examination has shown the specimen to be not a mineral species, but a mixture of about equal amounts of columbite and ferro-ilmenite, both of which minerals occur in the granite of Haddam. The metallic acids contained in this specimen are present in the following proportions:—

Ta_2O_5 . . .	= 32·39
Nb_4O_7 . . .	= 36·79
Il_4O_7 . . .	= 24·52
Np_4O_7 . . .	= 6·30
	100·00

The method adopted in separating the oxide of the new body rests on the inferior solubility of its soda-salt in boiling water. Neptunium appears to exhibit all the more important properties of the metals of the tantalum group, and evidently finds a place amongst them. From niobium and ilmenium it is distinguished by the fact of its fluoride forming with soda an amorphous insoluble precipitate; the other metals give crystalline precipitates, which dissolve in twenty-five parts of boiling water. It can be separated from tantalum by the property which its fluoride possesses of forming with potassium fluoride a salt which is easily soluble, the corresponding double compound of tantalum requiring 200 parts of water at 10° C. for its solution. The soda-salt of the new element colours a bead of microcosmic salt golden-yellow, while the other metals comport themselves under similar circumstances in the following characteristic manner: tantalum,

colourless; niobium, blue; and ilmenium, brown. Hermann refers to other reactions which serve to identify it. He has determined the atomic weight of neptunium by an analysis of the neptunium-potassium fluoride ($4\ K\ Fl + Np_2\ Fl_7 + 2\ H_2\ O$) and finds it to be 118·2. The combining numbers of the metals of this group form the following series:—

Tantalum	176·
Neptunium	118·2
Niobium	114·2
Ilmenium	104·6

The metal itself has not yet been prepared, the author having at present only forty grains of the hydrate of the metallic acid for investigation. Assuming, however, that neptunic acid ($Np_4\ O_7$), obtained by igniting the hydrate, is similarly constituted to the corresponding oxide of niobium, he calculates its specific gravity and atomic volume. He finds the density of neptunium to be 6·55, and the atomic volumes of the metals of this group form the following series:—

Tantalum	. . . . .	=	16·5
Niobium	16·5 + (1 × 0·5) .	=	17·0
Ilmenium	16·5 + (2 × 0·5) .	=	17·5
Neptunium	16·5 + (3 × 0·5) .	=	18·0

While the precipitate formed on the addition of soda to the fluoride of the new metal is, as has been stated, insoluble, neptunic acid when fused with soda and treated with boiling water dissolves in that menstruum, and prismatic crystals separate from the liquid as it cools. Tantalum, on the other hand, when similarly treated, deposits crystals which have the form of hexagonal plates.—*Journal für praktische Chemie*, 1877, xv., 105.

Trimethylamine.—Vincent directs attention to the value of this compound in analysis. After describing the mode of preparation he refers to some of its reactions which differ in many important respects from those of ammonia. With trimethylamine the salts of aluminium form white gelatinous precipitates which dissolve in an excess of the reagent. The salts of cobalt, nickel, copper and zinc form precipitates which do not disappear on the addition of a large excess of trimethylamine. The salt of silver forms a dull grey-coloured precipitate which dissolves in a large excess of the compound ammonia; the chloride of this metal, on the other hand, appears to be quite insoluble in trimethylamine. A substance which exhibits reactions so strongly contrasted with those of ammonia cannot fail to be of great use in special branches of practical chemistry.—*Bull. Soc. Chimie, Paris.*, xxvii., 194.

The Chemical Composition of the Flesh of the Halibut.—The halibut (*Hippoglossus americanus*, Gill), which abounds in the waters of the Atlantic, as far north as Newfoundland and as far south at Cape Hatteras, is highly valued as food in the United States. The flesh is of a fine white colour, is delicate and tender, and resembles that of the whiting (*Merlangus vulgaris*). The fresh flesh of the halibut has been analysed by Chittenden, and he gives in his paper the results of his examination side by side with those of

Payen, who investigated the composition of the flesh of the whiting. They are as follow:—

	Halibut.	Whiting.
Water	82·87	82·95
Solid constituents	17·12	17·05
Ash	1·08	1·08
Fatty matter	1·26	0·38
Nitrogen	2·01	2·41

The flesh of the American fish, when dried at 100° C., was found to consist of—

Carbon	50·38
Hydrogen	7·43
Nitrogen	11·68
Oxygen	6·35
Ash	24·16
	100·00

and of the above constituents 7·11 per cent. were present in the form of fatty matter. The ash of the flesh of this fish is composed of—

Silicic acid	0·32
Chlorine	11·11
Carbonic acid	1·13
Sulphuric acid	1·30
Phosphoric acid	34·36
Iron	0·19
Lime	0·15
Magnesia	2·43
Potash	37·07
Soda	12·22
Lithia	trace.
	100·28

Some considerable part of the alkaline metals which the author gives as oxides in the above percentage numbers must in reality be present in the form of *chlorides*, combined with the 11·11 per cent. of chlorine, and the total constituents found must therefore fall short of the total above given. In fact, the 11·11 per cent. of chlorine has, so to speak, been left out in the cold, uncombined, and must take the place of oxygen in these calculated results; this will reduce the total considerably. More than 70 per cent. of the constituents of the ash, according to the author's mode of regarding them, consists of phosphoric acid and potash.—*American Journal of Science*, 1877, x., 111–123.

The Estimation of Nitrogen in Nitrates.—The method recommended by Thorpe in his *Quantitative Chemical Analysis* for the determination of nitrogen in nitrates, has been examined by S. W. Johnson, of Yale College. The plan referred to consists in reducing compounds containing nitric acid to the form of ammonia by the use of strips of zinc covered with copper, by the "couple," in short, devised by Gladstone and Tribe. The author

gathers from Thorpe's paper that "the results are such as apparently establish its great exactness, while in simplicity and ease of execution it would seem to be quite superior to the similar methods which have been previously proposed." The first determination which Johnson made by Thorpe's process showed a deficiency of 45 per cent. In a second experiment nitric oxide was evolved, "the standard acid not only not being neutralized by ammonia, coming from reduction, but made more acid by the reaction of nitric oxide upon the oxygen and water of the condensing vessels." In the third and fourth experiments the results were equally unsatisfactory. The author then made three determinations by Bunsen's method with zinc-iron couples and caustic potash, and obtained concordant and perfectly satisfactory results, the numbers, it should be stated, being uniformly 0·3 to 0·6 per cent. under that required by theory.—*American Journal of Science*, April, 1877, xiii., 260.

The Protection of Iron against Rust.—A most important method has been devised by Professor Barff for preserving iron from rust. As far as we are able to judge from the results of the experiments which have thus far been made, the process is one of manifold application, and bids fair to prove of the greatest service in many branches of industry. Professor Barff has discovered a means of rendering all kinds of ironwork, however much exposed to the weather or to corrosive vapours and liquids, practically indestructible and permanent. Iron when exposed to the action of water or moist air begins to rust, a film of ferrous oxide being in the first instance formed upon its surface; this rapidly takes up more oxygen from the air, and a higher oxide, the sesquioxide, is formed; the latter compound gives up some of the oxygen to the unchanged metal beneath it, and the fresh ferrous oxide thus produced slowly unites with more oxygen, which traverses the porous layer of sesquioxide overlying it; in this manner the change is propagated to greater and greater depths, until in process of time the whole of the metal may be converted into rust. Various methods are employed to check this oxidation; paints and varnishes are used with, however, only partial success, from the fact that the adhesion of those materials to the metallic surface is imperfect, and they are liable to scale off and disintegrate with changes of temperature. Professor Barff proposes as a remedy the covering of the face of the metal with a layer of the oxide of iron, intermediate in composition between the two compounds we have above alluded to, the ferroso-ferric or magnetic oxide; and this he accomplishes by exposing the metal to the action of superheated steam at a high temperature. Iron treated in this manner for from six to seven hours at 1200° F. becomes covered with a black film of magnetic oxide, which adheres to it even more firmly than the metallic particles adhere to each other, and is sufficiently hard to resist the action of a file. At his lecture delivered before the Society of Arts, and subsequently at a soirée held in the Royal Society's rooms, Professor Barff showed specimens, treated by his method, which had passed unscathed through a six weeks' exposure to bad weather on a lawn in Bayswater, as well as others which had been lying in contact with corrosive liquids of every kind in the sink of a laboratory. It is easy to conceive of applications being made of Professor Barff's method which may prove of the greatest value and importance. Among many which have been suggested are the

protection of the plates of steam-boilers and of iron ships, the use of iron saucepans in place of tinned vessels, iron for many domestic purposes replacing the more costly copper; and we may, moreover, look forward to the time when leaden pipes for the conveyance of water will be entirely superseded. Again, there is every reason to suppose that this new process possesses many advantages over "galvanizing" applied to materials made of iron.

Succinic Acid in the Juice of the Unripe Grape.—During an examination of the juice of the unripe grape, conducted by Brunner and Brandenburg, with the hope of detecting as constituents glyoxylic acid and desoxalic acid, these observers recognized the presence in considerable quantity of succinic acid. The expressed juice of fruit, gathered in the middle of June, formed the material. After treatment with lime carbonate, and the removal of protein compounds by raising the liquid to the boiling point, the filtered liquid was concentrated and further purified with animal charcoal; a crystalline body was at length obtained, which proved on analysis to be calcium succinate. The acids sought for were not met with, and this failure to detect them is ascribed to the possibility of the grape having reached to an advanced stage of its development; the authors therefore intend to repeat their experiments with fruit at a still earlier period immediately after flowering. If they succeed in proving glyoxylic acid to be a normal constituent of the plant, a conception of the gradual conversion of carbonic acid into the vegetable acids under the reducing action of light may be arrived at —a metamorphosis in harmony with reactions which can be performed in the laboratory. The acids referred to, as well as others met with in vegetable tissues, might then be regarded as successively derived from a hypothetical carbonic hydrate by the following stages of reduction:—

$$2(CH_2O_3) + H_2 = \underset{\text{oxalic acid}}{C_2H_2O_4} + 2H_2O$$

$$C_2H_2O_4 + H_2 = \underset{\text{glyoxylic acid}}{C_2H_2O_3} + H_2O$$

$$C_2H_2O_3 + H_2 = \underset{\text{glycollic acid}}{C_2H_4O_3}$$

$$2(C_2H_2O_3) + H_2 = \underset{\text{tartaric acid}}{C_4H_6O_6}$$

$$C_4H_6O_6 + H_2 = \underset{\text{malic acid}}{C_4H_6O_5} + H_2O$$

$$C_4H_6O_5 + H_2 = \underset{\text{succinic acid}}{C_4H_6O_4} + H_2O$$

Oxalic acid is present in the leaves of the vine, according to Neubauer, who found it to be abundantly present, as well as some malic acid, in the wines of inferior vintages like that of 1871. Malic acid is not met with in wines of good vintage, although it occurs plentifully in the leaf of the vine at a certain stage of its growth. Neubauer also found succinic acid in the spring sap of the vine, and Gorup-Besanez detected the presence of glycollic acid and malic acid in the leaves of the Virginian creeper.—*Zeitschrift für analytische Chemie*, 1877, xvi., 246.

Nucite.—Tanret and Villiers have isolated and analysed a crystallizable sugar which occurs in the leaf of the walnut. It crystallizes in clinorhombic prisms

which have the specific gravity 1·54 at 10° C., and melt at 208° C. This body, which has been found on analysis to have the composition indicated by the formula $C_6H_{12}O_6 + 2H_2O$, does not reduce an alcoholic solution of a copper salt, and cannot be fermented. When oxidized with nitric acid it does not yield muric or oxalic acid, but forms a new body, the properties of which have not yet been investigated. Nucite, the name which the authors have given to this variety of sugar, is a body which closely resembles inosite in its characters.—*Comptes rendus*, Feb. 26, 1877.

GEOLOGY AND PALÆONTOLOGY.

The Mosasauridæ.—Professor Owen lately read a paper before the Geological Society, on the rank and affinities of the Mosasaurians, that curious family of Reptiles, the remains of which were originally discovered in St. Peter's Mount, near Maestricht. The Maestricht species was referred to the Cetacea by the great anatomist Campu, and to the Crocodilia by Faujas de St. Fond, whilst Cuvier regarded it as a true Lizard. Lately numerous remains of similar animals have been found in the Cretaceous rocks of America, and in examining these Professor Cope was led to recognize in them certain affinities to the Serpents; he spoke of them as "veritable sea-serpents," and formed them into an order which he called Pythonomorpha, in allusion to its supposed Ophidian characters. Professor Owen discussed in detail the various characters presented by the remains of these animals, and from his examination of these drew the following conclusions:—In the single occipital condyle and the composite structure of the mandible the Mosasaurians are Reptilian, as also in their procœlian vertebræ; in the double occipital hypapophyses, the bifurcate and perforate parietal, the presence of the "columella," the composite formation of the suspensory joint of the tympanic and in the type of the tympanic, the frame of the parial nostrils and the structure and attachment of the teeth, they are Lacertian. In one special dental modification they are Iguanian, in another Monitorial, and their special group characters consist in the more extensive fixation of the pterygoids and ossification of the roof of the mouth, the large proportion of the vertebral column devoid of zygapophyses, the confluence of the hæmal arch with the centrum in certain of the caudal vertebræ, and the natatory character of the fore and hind limbs. These distinctive characters did not appear to the author to be sufficient for ordinal rank, and with Professor Gervais he regarded the Mosasauridæ as a family of Lacertilia, equivalent to the Iguanodontidæ and Megalosauridæ in the order Dinosauria. The order Lacertilia among Reptiles, being equivalent to the order Carnivora or Feræ among Mammals, the Mosasaurians would be the equivalent of the Seals in the latter.

Hyænarctos in England.—In 1836 Messrs. Falconer and Cautley described a fossil from the Sewalik Tertiaries under the name of *Ursus sivalensis*, regarding it as a true Bear. In 1837 Wagner recognized its distinctness from the true *Ursi*, and established a genus for it under the name of *Agriotherium*, whilst in 1841 De Blainville gave no less than two names to the genus,

namely, *Amphiarctos* and *Sivalarctos*. This fortunate fossil had thus at least three generic names appropriated to it; but this was not enough. At some later but uncertain date the original describers of the species proposed for it the name of *Hyænarctos*, which has been adopted to the exclusion of all the others. Of late years examples of the genus have been found far from the original habitat, namely, in the Pliocene marine sands of Montpellier (*Hyænarctos insignis*), and in Miocene deposits at Sansans (*H. hemicyon*), and at Alcoy, in Spain. The range of this Sewalik form is now shown to be still wider by the discovery of two upper molar teeth, which are undistinguishable from the corresponding teeth of *Hyænarctos sivalensis*, in the Red Crag deposits of Waldringfield, Suffolk. These were lately described by Professor Flower, in a paper read to the Geological Society.

Ichthyosauri in the Rhætic Beds of the Saone-et-Loire.—M. H. E. Sauvage notices the occurrence of remains of animals of the genus *Ichthyosaurus* in the Rhætic beds of Antilly and le Coudre, in the department of the Saone-et-Loire. He refers the specimens found to two species, which he names *Ichthyosaurus rheticus and I. carinatus.* In the former the vertebræ of the middle portion of the dorsal region are strongly biconcave ; their longitudinal diameter is two-fifths of the transverse or vertical diameter, and their lower surface is flattened. The dorsal vertebræ of *I. carinatus* are more disclike. their longitudinal diameter being only two-sevenths of their transverse diameter; and the lower surface has a median keel, on each side of which there is a deep impression. M. Sauvage gives no indication of the size of these vertebræ.—*Ann. Sc. Géol.*, tome vii.

Veins of Bitumen in Granite.—M. A. Julien records the occurrence, in the granite of the neighbourhood of Clermont-Ferrand, of distinct bituminous veins. They are found in a railway cutting between Royat-les-Bains and Votrie, where they form a sort of network. The bituminous substance is sometimes black and soft. In other places it is a solid, brilliant asphalte, with a resinous lustre, a conchoidal fracture, and a brownish or blackish-brown colour, and forms veins varying in thickness from two or three lines to two or three centimètres. At the first glance it might be taken for brown flint, but it fuses at the temperature of boiling water, and burns with a clear flame, producing a strong and characteristic odour.—*Comptes rendus*, April 9, 1877.

Diffusion of Strontian in Nature.—M. Dieulafait, in a memoir presented to the French Academy of Sciences (" Comptes Rendus," June, 1877), gives the results of his investigations upon this subject, which are of interest in themselves and as bearing upon the general question of the mode of occurrence in nature of comparatively rare substances. His experiments appear to have been carried on chiefly by means of the spectroscope.

M. Dieulafait finds that strontian exists in sea-water as carbonate and sulphate. In the former state it may be recognized in 100, in the latter in 4 cubic centimètres of water. The gypsum formed in salt marshes before the deposition of salt contains strontian in such quantity that 1 milligramme of the substance distinctly gives its spectrum; and as in the evaporation of sea-water the strontian is always thrown down in the precipitates of carbonate and sulphate of lime which are first produced, it is naturally missing in the sodium chloride and other salts afterwards produced. As strontian is always associated with the carbonate and sulphate of lime dissolved in

sea-water, it ought also to occur in the hard parts of marine organisms consisting of those salts; and M. Dieulafait has always found it in them with a weight of not more than 1 centigramme. A further investigation showed that this rule applied also to the fossil remains of organisms, for 120 species of Brachiopoda, from the whole series of formations from the Silurian upwards, all furnished the spectrum of strontian with quantities of substance less than 1 centigramme. In the author's opinion all deposits of gypsum, of whatever geological age, have been produced simply by the evaporation of sea-water at the ordinary temperature of each epoch; and if this view be correct, and the seas of all times had the same constitution all specimens of gypsum ought to contain strontian. This was found to be the case in 188 samples of Triassic gypsum, 85 of Tertiary gypsum, 4 of gypsum with mica (so-called metamorphic gypsum), and 6 specimens of the ophitic deposits of the Pyrenees, and the strontian was found to be pretty uniformly diffused throughout the mass of each deposit. In mineral waters also, as might be expected, strontian is at least very generally present in variable quantities.

MINERALOGY.

Heubachite.—Sandberger has given this name to a mixture of the hydrated oxides of cobalt and nickel (with a little iron and manganese oxide) which occurs in black flakes and occasional spherular forms, on the heavy spar of the St. Anton mine, in the Heubach Valley, near Wittichen. It has the hardness 2·5, a density of 3·44, and contains 65·5 per cent. of cobalt oxide and 14·5 per cent. of nickel oxide.—*Neues Jahrbuch für Mineralogie*, 1877, 299.

Sellaite.—Six years ago Strüver discovered a colourless transparent mineral associated with anhydrite at Geibroula, in Piedmont. Small fragments of this mineral were found to melt in the flame of a candle, and to be insoluble in water and in all acids with the exception of sulphuric acid, which caused the evolution of hydrofluoric acid. The acid solution contained 39·64 per cent. of magnesia, and the chemical and physical characters of the mineral led Strüver to regard it as a magnesium fluoride analogous in composition to fluorspar. It received at the time the name given above. Cossa, of Turin, has recently noticed that the white amorphous powder having the composition $Mg\,Fl_2$ separates, after fusion with potassium or sodium chloride, in brilliant crystalline plates. The pure fluoride fuses at the temperature at which cast iron melts, and forms on cooling large crystals having the specific gravity of 2·856, and possessing identically the same form as Strüver's mineral, which he found to be quadratic. Both the mineral and the artificial product are phosphorescent, exhibiting a violet light.

The Origin of Mineral Oils.—At a recent meeting of the Russian Chemical Society, Mendelejeff presented a report on his examination of the deposits of mineral oil in the Caucasus and in Pennsylvania, and propounded a new and interesting theory as to its probable origin. He questioned the accuracy of the view generally held, of the oil being a product of the decomposition of the fossil remains of organisms. The occurrence of the oil near the earth's surface is

to be attributed to the tendency which it possesses to traverse higher and porous sedimentary deposits when exposed to the action of water universally present, and of greater density than itself. The beds of sandstone in which much of the oil is met with do not appear to contain the remains of the organisms to which its origin is ascribed, and the geologist is driven to seek at greater depths the materials which yield it. In the Caucasus the oil occurs in Tertiary beds; in Pennsylvania, in Devonian and Silurian rocks. But, the author maintains, we have no grounds for believing in the occurrence of any extensive deposits of organized structures at a period earlier than the Silurian, and the prevailing view, therefore, can hardly be considered to meet the difficulty. Mendelejeff refers to the theories put forth by Laplace and others respecting the probable mode of formation of our globe, its density as compared with that of the surface layers, so far as we are acquainted with them, &c., and draws attention to the possibility of the interior of the earth containing metallic masses of vast extent. If it be allowed that iron is the prevailing metal—and its presence in great quantities in the sun and in meteorites renders his theory a not improbable one—and that metal occurs in combination with carbon, we have the material from which we can conceive the mineral oil to have been derived. Contact with water at high temperatures, and under great pressure, brought about by the upheaval or disruption of any of the overlying sedimentary strata, would result in the formation of metallic oxides and saturated hydrocarbons. The latter, permeating the porous sandstones of higher levels, would condense there, or, after undergoing further change, become the marsh gas of the "gas-wells," or be converted into unsaturated hydrocarbons. The invariable association of salt water with mineral oil is not without its bearing on this interesting question. If the view recently advanced by Steenstrup, that the remarkable metallic masses, discovered by Nordenskjöld, in 1870, at Ovifak, Disko Island, Greenland, and generally held to be blocks of meteoric iron, be a correct one, and they are really erupted matter and not of cosmical origin, they narrowly resemble, as regards their composition, which analysis has shown to be to a considerable extent carbide of iron and magnetite, the material which Mendelejeff assumes to be the source of the oil.

Ihleite.—Schrauf has given this name to a ferric sulphate which he has found on the graphite of Mugrau, in Bohemia. It is a product of the decomposition and oxidation of the pyrites disseminated through the graphite, and occurs as a fine orange-yellow efflorescence upon its surface; it exhibits the botryoidal characters of botryogen. It has a density of 1·812, and is soluble in cold water. Specimens which were collected in 1875 and the following year were found to have the following composition:—

	1875.		1876.
Sulphuric acid	38·2	37·4	37·2
Iron protoxide	2·1	} 26·1	1·4
Iron peroxide	} 24·5		} 25·6
Alumina		0·3	
Lime		0·4	0·8
Water	35·5	35·6	35.3
	100·3	99·8	99·8

These numbers closely accord with those required by the formula Fe_2O_3 $3SO_3$ $12H_2O$, and ihleite appears to be a distinct mineral species; it differs from the coquimbite, analysed by Gustav Rose, in containing 12 in place of 9 equivalents of water.—*Neues Jahrbuch für Mineralogie*, 1877, 251.

PHYSICS.

The Electric Conductivity of Water.—It seems at first sight curious that in the case of so common a substance as water there should be any doubt among physicists as to the power which the liquid possesses of conducting electricity. Not that the subject has by any means been neglected, as the labours of Magnus, Pouillet, Becquerel, Oberbeck, Rossetti, and Quincke abundantly testify. But the results obtained by these several investigators differ so widely among themselves that it is not easy to know which are to be accepted. The figures brought out by Pouillet, for example, are sixty times greater than those deduced by Magnus. Professor Kohlrausch has, therefore, thought it high time that the subject was settled; and after a most carefully conducted investigation, he has published the results of his inquiry in Poggendorf's "Annalen" (*Ergänzungsb.* iii. 1877, p. 1). Many substances have their electric conductivity affected to a remarkable extent by the presence of impurities, even when these are present in only minute proportion. Matthiessen showed that copper, for instance, has its conductivity lowered 40 per cent. by presence of a mere trace of arsenic. In like manner Kohlrausch has found it necessary to pay scrupulous attention to the purity of the water which he examined, and indeed the discrepancies among the results of previous inquirers may probably be explained by inattention to this point. Having prepared the liquid in as pure a state as the resources of the laboratory can permit, Kohlrausch tested the conductivity by examining a shell of this water enclosed between two hemispherical vessels of platinum nearly fitting one into the other, and serving as electrodes. On passing a current of electricity through this arrangement, it was found that the pure water offered remarkable resistance; in fact its conductivity was only $\frac{1}{120}$ of that assigned to it by Pouillet. Rain, which is, of course, the purest natural form of water, conducted electricity twenty-five times better than the artificially-purified liquid which served as a standard.

Influence of Light on the Electric Resistance of Metals.—Some two or three years ago we were startled by the announcement that the electric conductivity of selenium is capable of being affected by light. It has, however, been since determined that not only selenium but also the allied element tellurium has its electric resistance diminished after exposure to luminous rays. Desirous of determining whether other bodies are similarly affected, Dr. Börnstein has carried out some interesting researches in the Physical Institute at Heidelberg. His results are published in a paper which has been translated by Mr. R. E. Day, in the "Philosophical Magazine" (June, 1877, p. 481). Gold, silver, and platinum are the only metals which Dr. Börnstein has yet examined, but as he finds that all these are sensitive to

light, he is inclined to infer that the property, so far from being exceptional, is one enjoyed in greater or less measure by all metals. In the case of selenium and tellurium, it has been suggested that the alteration of resistance is due to the action of calorific rather than of luminous rays. But no such objection can be urged against the experiments with the noble metals. In fact, the resistance of these metals *increases* with the *temperature*, so that when it is found that on exposure to direct light the resistance is diminished, it is clear that heat can have nothing to do with causing such a change. Heat, indeed, tends to mask the effects of light, and the diminution of resistance is therefore a differential effect; an effect representing the difference between the increase of resistance consequent on rise of temperature, and the decrease of resistance due to the action of light. Dr. Börnstein's experiments, therefore, show beyond question that the electric conductivity of the noble metals is exalted, or their resistance diminished, by the direct effect of luminous rays.

The Electric Candle.—Experiments have been recently conducted at the West India Docks with the view of testing the illuminating power of the so-called electric candle devised by M. Paul Jablochkoff. This simple means of producing a steady electric light consists in placing two carbon pencils side by side, but separated by a bar of a composition called "kaolin." On the passage of the current the carbons slowly burn down, and the kaolin is consumed by the heat at exactly the same rate. The carbons are thus kept always at the same distance apart, and the light playing between them is thus rendered constant without the aid of complex regulators. In the experiments at the West India Docks the current was produced by a magneto-electric machine, worked by a small steam-engine, and the results are described as having been eminently satisfactory. For lights of small and medium size, an apparatus of even greater simplicity may be employed, the carbon points being dispensed with and nothing used beyond a piece of the so-called kaolin held between the electrodes. But M. Jablochkoff's prime improvement, which promises to greatly extend the use of the electric light, consists in his ability to divide the current, so as to supply several candles placed in the same circuit, each with its own coil. These candles may be of various degrees of illuminating power, and may be lighted or extinguished separately. In short, the electricity appears to be under such control, that it might be generated in some central establishment and laid on through wires to the several centres of illumination, just as freely as gas is at present distributed through pipes to any number of burners. MM. Denayrouze and Jablochkoff, who have employed the light in Paris, have described their process before the French Academy of Sciences.—*Comptes rendus*, No. 16, April 17, 1877.

Magnetization of Polarized Light.—It was Faraday who first showed, by a series of famous experiments, that magnetism is capable of exerting a remarkable influence on light which has undergone that physical change which is called polarization. When a beam of plane-polarized light is transmitted through certain transparent media placed between the poles of an electro-magnet, the plane of polarization is rotated in this direction or in that, according to the course which the electrical current is caused to take in circulating through the coils of the magnet. Dr. J. Kerr, of Glas-

gow, reflecting on this fact and others of a kindred nature, was led to institute experiments with the view of determining whether a beam of plane-polarized light, when reflected from an iron surface highly magnetized, would have its plane of polarization twisted in the act of reflection. A paper describing his experiments in detail, and corroborating his assumption, will be found in a recent number of the "Philosophical Magazine" (May, 1877, p. 321). An upright electro-magnet of horse-shoe shape had its polar surfaces polished so as to form reflecting planes. Moreover, a sub-magnet was employed to concentrate the magnetic force, by inductive action, upon the surface of the iron mirror. A beam of light polarized by transmission through a Nicol's prism was incident at various angles upon this mirror, and after reflection was analysed by passing through a second Nicol. Let these prisms be crossed so as to extinguish the light, and then send a current through the electro-magnet; as soon as the iron mirror becomes magnetized the obscuration is diminished, showing, of course, that the plane of polarization has been turned. The direction in which it is turned is contrary to that of the magnetizing current. If, for example, the magnetized iron mirror become a true south pole, then the plane of polarization is turned to the right hand; if the current be reversed, so that the magnet becomes a north pole, the rotation is to the left. It should be remarked that Dr. Kerr, following Sir W. Thomson, uses in this respect a different nomenclature from that popularly employed. His true south pole would be one that points, on the whole, towards the north; that is to say, what most people would call the north pole of the magnet. It seems reasonable enough that the great earth-magnet should have its south pole in the southern, and its north pole in the northern hemisphere. But if artificial magnets are to have their poles similarly named to the like poles of the earth, then (remembering that opposite poles attract) we shall have to call the true south pole of the magnet that which points to the magnetic north; in other words, we reverse the common nomenclature. It is in the highest degree desirable that uniformity should be attained, and confusion prevented, in the use of such common terms. Indeed, it has been suggested to abolish such phrases as the north and south ends of the needle, and to substitute others free from ambiguity.

Method of Determining Index of Refraction.—It is by no means an easy matter to determine the index of refraction of a solid substance, say, of a gem-stone, or other transparent mineral. And yet the refractive power is unquestionably an important physical characteristic, and one which would no doubt be often recorded if it could be measured with readiness. Mr. H. C. Sorby is therefore to be congratulated on placing in our hands a method of extremely simple application ("Mineral. Magazine," No. 4, 1877, p. 97). He takes a small piece of the transparent substance, having flat parallel sides, and placing it on the stage of the microscope, finds the thickness of the fragment, and also the extent to which the focal length of the object-glass is displaced by looking through this thickness of the medium. These measurements are effected by attaching to the body of the microscope a small graduated scale with a vernier, enabling the observer to read off to the thousandth of an inch. To make the two required measurements is but the work of a few moments, and having obtained these data, the index of

refraction is immediately calculated; it is, in fact, equal to the thickness divided by the difference between the thickness and the increase of focal length. By this method Mr. Sorby has already determined the index of refraction of a large number of substances, and has obtained some interesting results. For example, he finds that the mineral called Proustite, or light-red silver-ore, has a refractive exponent as high as 3·28; much higher indeed than that of any substance previously examined. It has been proposed at various times to construct microscopic lenses of diamond or sapphire, but although these gems have very high refractive indices, they are far exceeded in this respect by Proustite. In fact, were it possible to construct a lens of this rare mineral, it would have about twice the magnifying power of a lens of flint-glass of equal curvature. The index of flint-glass is certainly not higher than 1·6, which, as we have seen, is only about half that of Proustite.

The Half-prism Spectroscope.—Instead of the ordinary isosceles prisms used in our spectroscopes, Mr. Christie, of Greenwich, has recently suggested the introduction of half-prisms. By a "half-prism" we understand an ordinary prism which has been cut in half by a plane perpendicular to the base. Such a prism possesses peculiar advantages. Suppose two slightly divergent rays of monochromatic light to pass through an ordinary prism, the angle of separation will not be altered, so that the rays emerge at the same angle to each other which they had at entrance. But if two such rays fall perpendicularly upon a face of the half-prism, the deviation of one ray in traversing the glass will be much greater than that of the other, and they will consequently emerge separated by a much wider angle. In fact, the half-prism is really equivalent to a magnifier with cylindrical lenses. Mr. Christie has had several half-prism direct-vision spectroscopes successfully constructed by Mr. A. Hilger, and has described them before the Physical and Astronomical Societies ("Astron. Register," May, 1877, p. 111). Half a prism of flint-glass is cemented to a half-prism of crown glass, and a combination giving great dispersion is thus obtained. If the double sodium line be viewed through such a spectroscope, the two lines will be seen widely separated, and in consequence of the dispersion they will be broader than with an ordinary instrument. With two such half-prisms a dispersion equal to that of ten compound prisms has been obtained; and this, too, without any loss of definition. Moreover, either great dispersion or great purity of spectrum can be obtained at pleasure, according as the light is allowed to fall first upon the perpendicular or upon the oblique face of the half-prism. Hence by reversing a train of half-prisms, so that the light falls on the opposite side, a comparatively short spectrum is obtained, but one of great purity. Indeed, without use of collimating lenses or slit, the sodium lines may be seen in an ordinary unsalted candle-flame, and Fraunhofer's lines may be seen in the solar spectrum.

The Otheoscope.—So many different forms have been given to the radiometer by the ingenuity of Mr. Crookes, that at the Royal Society's *soirée* in April he was able to exhibit as many as twenty modifications of the little instrument. Among these modifications were several so different from the earlier forms of radiometer, that Mr. Crookes proposes to distinguish them as *Otheoscopes*, a name derived from ὠθέω, I propel. In an ordinary radio-

meter, whatever form it may assume, the glass globe is an essential part of the apparatus. Without the globe the fly would never turn, and the most probable view of the action of the radiometer—the view to which the inventor himself assents—is that rotation must be caused by the excess of molecular pressure between the fly and the enclosing vessel. In the otheoscope, on the contrary, the glass bulb serves merely as an envelope to enclose the rarefied air, and is by no means an essential part of the machinery. In fact, an otheoscope has been constructed without any envelope whatever. Let a radiometer and an otheoscope be removed to a position in space where the air is extremely attenuated, so that the atmospheric pressure is perhaps not more than a millimeter of mercury, and then remove the glass case from each instrument; the fly of the radiometer immediately would become stationary, though there might be abundant solar radiation, but the fly of the otheoscope would whirl round just as merrily as before. The first form of otheoscope described by Mr. Crookes ("Chemical News," May 4, 1877), consists of a four-armed fly, each carrying a vane of thin clear mica. At one side of the glass bulb which encloses the apparatus there is a vertical plate of mica blackened on one face, and so placed that each vane closely approaches it as the mill rotates. If light be allowed to fall only upon the clear vanes, no motion is produced; but if the light shine upon the black plate the vanes instantly begin to rotate, as though repelled by a molecular wind blowing from this surface. The movement is therefore produced by pressure generated on a fixed part of the apparatus, by which the moveable portion is propelled. As this driving-surface is stationary, it is not restricted in weight, size, or shape; and hence the modifications of which the otheoscope admits are well-nigh endless.

The Cycloscope.—It is well known that if a mirror be attached to a vibrating tuning-fork, and a point of light which moves uniformly in a plane at right angles to that in which the fork is vibrating be reflected from this mirror, the image will be an ordinary single wave. Again, if a series of luminous points move uniformly with such velocity that a point passes over two intervals during an odd number of vibrations of the fork, the two waves overlap and produce a double figure of the form of a series of figures-of-eight. Extending these principles, Professor McLeod and Lieutenant G. S. Clarke have recently constructed an ingenious apparatus which has been described before the Royal Society under the name of the cycloscope. Equidistant perforations are made in a circle on a disc, which is attached to a rotating axis, and the light passing through these apertures falls upon a vibrating tuning-fork of known period, whence it is reflected on to a screen; and from the shape of this reflected image the rate of rotation can be deduced. Hence the cycloscope promises to become of much value in determining the speed of machinery. On the contrary, if the speed at which the cylinder rotates be known, the pitch of the tuning-fork may be ascertained.—*Proc. Roy. Soc.*, April 19, No. 180, p. 157.

ZOOLOGY.

A New Larval Cestoid Worm.—In a paper read before the French Academy of Sciences ("Comptes rendus," May 14, 1877), M. A. Villot describes a most interesting larval parasite belonging to the group of Cestoid worms. One of the most remarkable things in connexion with it is the nature of its host, which is a Myriopod, the *Glomeris limbatus*, Lat.; the Cestoid worms in all stages being generally parasitic on vertebrate animals.

In its simplest stage it forms little separate cysts, lodged within the biliary vessels. These cysts, which are about 0·028 mm. in diameter, might easily be mistaken for *Gregarina*-cysts. They are composed of two transparent membranes, and contain two kinds of corpuscles—pale granulations of protoplasmic nature, and very refractive yellowish concretions, such as occur in all Cestoids. Each cyst can reproduce by gemmation after the fashion of a cell, and in this way these vesicles at last completely fill up the lumen of the vessel, forming milk-white masses, visible to the naked eye. The cysts then escape from the vessel into the body cavity, by traversing the wall of the former, to which they generally remain adherent by a pedicle. The multiplication still continues, so that the vessel is soon covered with innumerable cysts of different sizes, but all united by peduncles, and forming bunches, often of considerable size, and of a pearly-white colour.

The vesicles, which are now ovoid, have greatly increased in size, measuring 0·160 mm. in length by 0·140 mm. in breadth. Their envelope has also become thickened; its outer membrane is composed of transverse and longitudinal elastic fibres, forming two distinct layers; and its inner membrane exhibits the ordinary cells of connective tissue. At the anterior pole of the cyst there is a deep funnel-like depression, which is imperforate, and consists solely of a conical invagination of the two membranes. In the interior of the cyst there is a fine, perfectly recognizable *scolex* with four discs, a stout proboscis, and a simple circlet of fourteen hooks. These are 0·026 mm. long and 0·080 mm. broad at the process, which is remarkably developed.

From this description of the scolex there would appear to be no doubt as to the Cestoid nature of this parasite upon *Glomeris*, but so far as we remember the mode of development described is perfectly unique among the Cestoid worms. M. Villot, indeed, says that in its structure and encystation it much resembles the Echinococci; but at the same time he fully recognizes the great differences which separate it from those larval forms, and notices them as follows:—"In the true Echinococci," he says, "the acephalocyst takes no part in the budding, while in the Echinococci of *Glomeris* the budding affects the whole of the cyst and its contents. Hence, in the former case the budding is internal; whilst in the latter it is external. This essential difference in the mode of proliferation" he regards as necessitating the formation of a distinct genus, and he proposes to name the new parasite *Staphylocystis biliarius*, in allusion to the racemose arrangement of the cysts, and the connexion of the parasite with the biliary ducts. It is much to be

wished that the further development of this singular form of parasite may be ascertained. M. Villot states that he also finds a nematoid worm of the genus *Cephalobus* in the stomach of the *Glomeris*, which is very common in the limestone mountains surrounding the city of Grenoble.

Heterogeny in the Gallflies.—It has been long known to entomologists that while of some genera of the delicate little Hymenoptera which produce most of the excrescences on plants known as galls, in which their larvæ live and arrive at maturity, both males and females might always be reared, other nearly allied forms were only known by a single sex, none but females of them having ever been seen. This was strikingly the case with some of the Cynipidæ that infest the oak; and according to a communication made by M. J. Lichtenstein to the Entomological Society of France, Dr. Adler, of Schleswig, has devoted a good deal of attention to the investigation of these little insects, with most curious and interesting results. He finds that the phenomena in question constitute a case of heterogeny; that is to say, the agamic genera, or those of which females only are known, are only transitory forms, producing galls quite different from those from which they themselves issued, and giving origin to both male and female insects. In form and structure these two successive winged generations of the same insects present no resemblance to one another, and do not even belong to the same genus. This certainly constitutes the most remarkable instance of "alternation of generations" with which we are acquainted. Thus the common species, *Spathegaster baccarum*, which issues from the fleshy galls, like white currants, under the leaves of the oak, presents male and female individuals with rather short ovipositors. The females prick the young leaves, and thus give rise to galls quite different from those from which they emerged; namely, the small lenticular or "spangle" galls, from which *Neuroterus lenticularis* proceeds. In the genus *Neuroterus* there are only agamic (female) individuals, which have a very long ovipositor rolled up in the abdomen. They emerge in the winter, and lay their eggs in the buds of the oaks in March and April, thereby causing the formation, not of the lenticular autumn galls, but of the currant-like spring galls from which the *Spathegaster* is produced. Thus both the insects and the galls are exceedingly different. Dr. Adler has ascertained that this relation exists between several species of Cynipidæ, of which the following is a list:—

Neuroterus fumipennis	is the agamic form of	*Spathegaster albipes.*
,, *lenticularis*	,,	*Spath. baccarum.*
,, *numismalis*	,,	,, *vesicatrix.*
Dryophanta scutellaris	,,	*Trigonaspis crustalis.*
,, *longiventris*	,,	*Spathegaster Taschenbergi.*
Aphilothrix radicis	,,	*Andricus noduli.*

Parthenogenesis in Ants.—In his paper on the habits of ants ("Journ. Linn. Soc.," Zool., Vol. xiii., No. 63), a short notice of which appeared in our last number, Sir John Lubbock refers to the occurrence of true parthenogenesis among those insects. He finds that, as among bees and wasps, the workers occasionally, although rarely, lay eggs. His observations do not enable him to say whether these necessarily unfertilized eggs produce males,

as is known to be the case in bees and wasps, but the following statement would seem to show that they do so. Sir John Lubbock says:—"I have a nest of *Formica cinerea* which I brought from Castellamare, in December 1875, and which has no queen; nevertheless eggs were laid in it last spring, and these eggs produced winged individuals only, all, I believe, males; but, unfortunately, they emerged one day when I was away from home, and I lost the opportunity of examining them carefully. None of the eggs, however, produced workers."

The Lower Sarcode Organisms.—In his Presidential addresses to the Linnean Society for the present year and 1876, Professor Allman has noticed the progress made in the knowledge of those low forms of animals which, consisting almost wholly of undifferentiated sarcode, may be looked upon as occupying the very lowest step in the series of animal organisms, even if we decline to refer them, with Häckel, to the neutral group of the Protista. The address for 1876 is just published in full in the "Journal" of the Society; it is fully illustrated, and contains an admirable summary of the results of recent researches upon the lowly organisms of which it treats.

In his address delivered on the 24th of May last Professor Allman remarked that to the investigations of Archer and others in this country, and of Hertwig, Lesser, Schulze, and Greeff, in Germany, much of our knowledge of the Monothalamic Rhizopods of freshwater is due. These latter forms may be divided in accordance with the nature of their pseudopodia, in some these processes being short, thick, and finger-shaped (Lobosa); in others long slender threads (Filifera).

Quadrula with a sculptured shell illustrates the former, and the still more curious *Microgromia socialis* the latter. This last forms colonies united by a network of gelatinous threads. Moreover, Hertwig has shown that the protoplasm of *M. socialis* divides by spontaneous fission into two segments, one of which remains in the shell; the other, forcing its way out, assumes an oval shape, and develops vibratile flagella, and not pseudopodia, thus becoming a free-swimming flagellate zoospore capable of ultimate development into the adult form. The importance of Häckel's discovery that starch is contained in the so-called "yellow cells" of the Radiolaria was referred to. Messrs. Dallinger and Drysdale have shown that the flagellate monads may acquire an amœboid condition, and move about by the aid of pseudopodia; that two such amœboid forms, when they come in contact with one another, become instantly blended together at the point of contact, and ultimately fused together throughout, when their mingled protoplasm assumes the form of a spherical sac filled with particles of immeasurable minuteness. These particles are germs destined for the reproduction of the individual. Their form can be demonstrated only by the highest powers of the microscope, such as the 1-50 inch object-glass. Not only has their development into the adult form been traced, but the unexpected fact has been elicited that these germs can be subjected to a temperature of 258°-300° Fahr. without losing their vitality and power of development—a fact of vast significance in its bearing on experiments connected with the question of spontaneous generation. Hertwig and Schulze have quite recently made the discovery of a nucleus in the Foraminifera. This group, therefore, must now be removed from the region of Cytodes, or non-nucleated protoplasmic masses, and

placed in a higher stage in the great division of the Rhizopoda. From facts such as these F. E. Schulze conceives he has got a clue to the affinities and derivation of the various members of the Sarcode organisms, Rhizopoda. The primitive forms, non-nucleated Cytodes, Häckel's Monera (*Protogenes*, *Protamœba*, &c.), Schulze regards as the lower undivided stem. From these, by differentiation of a nucleus in their protoplasm, are evolved the nucleated forms (*Amœba*, freshwater Monothalamia, Foraminifera, Heliozoa, &c.), which constitute the subdivisions into which the stem branches off. These repeat the various modifications of pseudopodia (Lobose, Filiform, &c.), which have already existed in the primitive forms, and which they thus derive by inheritance from their non-nucleated progenitors. Finally, through the branch of the Heliozoa, we are conducted to the ultimate twigs formed by the families of the Radiolaria, in which we find not only nuclei but a "central capsule," indicating the highest grade attained by any member of the group.

The so-called "Colonial Nervous System" of the Polyzoa.—In 1860, Fritz Müller described a series of cords with ganglionic inflations which he had found traversing the stem and branches of the polyzoary in *Serialaria Coutinhii*, a polyzoan of the Brazilian coast, and which he regarded as a "colonial nervous system" destined to transmit sensations to different parts of the common structure, and probably to govern the movements of the zooids. Other observers, especially Smitt and Claparède, detected something of the same kind in European species of Cheilostomatous Polyzoa, and M. L. Joliet has recently communicated to the French Academy of Sciences ("Comptes rendus," April 9, 1877), the results of his observations on *Bowerbankia imbricata*, Johnst., a species which, with its congener, *B. densa*, Farre, is particularly well adapted for such investigations.

The colonial nervous system in *Serialaria*, as described by Fritz Müller, consists of the following parts:—1. A central cord which traverses the length of each joint of the stem, and divides distally into as many branches as the joint gives off ramifications; 2. Granular ganglia placed at the bases of the branches and of the zoœcia, or cells of the individual polypides; 3. A plexus superadded to the central cord and uniting the ganglia of the branches and zoœcia; 4. A nerve which runs from the ganglion at the base of each zoœcium to the bud and to the intestine of the adult polypide. All these parts are equally distinct in *Bowerbankia imbricata*, but some of them bear a very different interpretation from the above.

In this species, according to M. Joliet, the central cord consists of large fusiform cells, not containing a distinct nucleus, but a very variable number of refractive granules. These cells agree with no known nervous element. The plexus possesses the same structure as the central cord; and its branches, instead of running to some particular point, or to some organ, such as the muscles, generally go to indeterminate points in the walls of the cell where there would appear to be no movement to produce or sensation to perceive, and here, instead of forming something like an ordinary nervous termination, they become confounded with the endocyst. With regard to the ganglia, Fritz Müller would appear to have been misled by appearances. According to M. Joliet, at the level of the articulations there are diaphragms, which have been already noticed by Reichert in *Zoobotryon pellucidus*, and which cut

the supposed ganglia into two parts, communicating only by a narrow perforation in the diaphragm. The so-called ganglia are, in fact, simply appearances produced by the juxtaposition on the two surfaces of a thin diaphragm of two masses of granular matter produced by the spreading out, on these surfaces, of the central cord of the corresponding joint.

The supposed nerve which runs from the basal ganglion of the zooecium to the bud is actually attached, as Fritz Müller thought, to the intestine of the adult polypide, but, according to M. Joliet, it is nothing but the organ described by previous authors under the name of the *funicle.* It has the same structure as the central cord, and it is so contractile as to act the part of a third retractor muscle. It has therefore no resemblance to a nerve.

From all these circumstances M. Joliet concludes that this system of organs is not nervous in its nature. Further, he finds by experiment that pinching or even cutting the central cord has no influence upon the polypides which might be expected to be acted upon, and hence concludes that it does not transmit sensation. He is still engaged in investigating its nature, but in the meantime states that the fusiform cells of which it is composed may often be seen to swell and become rounded, and then detach themselves from their neighbours, giving origin to a number of floating corpuscles which are observed in the liquid filling the joints of the stem and the cavities of the zooecia of the *Bowerbankia.* As these Polyzoa are found on the British coasts, some of our readers may find an interest during the coming vacation time in investigating this curious problem.

THE VOLCANOS OF THE HAUTE LOIRE AND THE ARDÊCHE.

BY THE REV. W. S. SYMONDS, OF PENDOCK.

(*Concluded from* p. 260.)

[PLATE VIII.]

WE shall long remember our days on Mont Denise when endeavouring to separate the newer geologic phenomena from the older. It was glorious sunny autumn weather, the distant views being wonderfully clear and distinct, and wild pinks blossoming wherever a tuft might grow among the cinders. There was *Dianthus superbus* and several other pinks which we did not know, with convolvuli and other autumnal plants, which were most abundant in the woodlands on the slope of the hill. The different views from various points of Mont Denise embrace the principal features of this extraordinary country. The following plants were noted by Sir W. Guise as growing on Mont Denise and near Polignac in the month of June: *Biscutella lævigata*, *Saponaria ocymoides*, *Coronilla varia*, *Dianthus* (two species), *Linaria striata*, *Mulgedium Plumieri*, *Rosa rubiginosa*, *Muscari comosum*, *Specularia speculum*, *Centaurea cyanus* and *calcitrapa*, &c.

Mr. Scrope believed that the noble ranges of basaltic columns, the Croix de la Paille and the Orgues d'Espailly, belong to the later volcanic outbursts from Mont Denise. The Croix de la Paille projects from the flank of the hill; but there are no means of determining the relation of this basaltic outflow to the tuff and scoriæ which cover the slopes of the hill, nor is it easy to say why these columnar rocks should not be as ancient as the older conglomeratic tuffs or breccias. The structure of the Orgues is very beautiful; and we are struck with the symmetry of the columns, which are 50 feet in height. The basalt overhangs the river Borne, but does not occupy the existing channel. There is an outlying mass also of columnar basalt, called Mont Redon, which has overflowed an ancient bed of the Borne at the height of 50 or 60 feet above the present channel. These

masses of basalt appear to me to have been local outbursts. A similar history belongs to the columnar basalts of Monistrol on the Allier south-west of Le Puy and Bains. They overlie old river beds of a former Allier, but are not excavated by the present river, for it now runs through the decomposing granite.

A pleasant walk from Le Puy through Brives and over the bridge on the Loire conducts us to a tributary of the Loire, and on the right bank of this stream is the Roche Rouge. This is a basaltic dike traversing granite, and is remarkable as showing the wearing away of the granitic rock by atmospheric influences, since the infiltration of the dike into a fissure, and the resistance of the Roche Rouge to the eroding agents. It is a romantic spot, the stream of the Lagogne flowing in a narrow channel through granitic rocks, and forming deep pools in which we saw trout shooting in and out of hollows in the rocks. Wild pinks were growing all around, and the tall pyramid of the Roche Rouge rises 200 feet above the river. The roadside between the river and the base of the basaltic dike exhibits an old river bed, many feet above the present stream. We traced the dike upwards nearly to the summit of the hill, and found that the granite immediately in contact with the igneous rock had decomposed much more than that at a distance from the point of contact. We observed also that, even on so isolated a spot, vegetation was far more luxuriant on the lava than it was on the granite. Wild flowers blossomed everywhere on the Roche Rouge, accompanied by butterflies hovering around, while hardly a plant flourished on the arid unfertile granite. Another dike cuts through the freshwater beds at Brunelet on the road from Le Puy to Issingeaux.

Standing on Mont d'Ours or any of the heights above Le Puy, and looking westwards, we see the granitic range of La Margeride rising between us and the old miocene volcano of the Cantal, while southwards are the heights of Mezen. Mont Mezen itself is nearly 600 feet above the sea; but the old volcano was probably much higher, as it was erupted on a much more elevated basis of granitic rocks than either the Cantal or the Mont Dore. Opposite Mont Denise, on the other side of the Borne, the basaltic plateau shows trachytic lavas overlying basalt, as if produced by separate outbursts. The demarcation of the two lavas may be seen even across the valley from Denise.

An expedition may be made from Le Puy to the ruined castle of Lardeyrolle, which lies on the left of the road to Issingeaux and Arnoray. Here, in the middle of the sixteenth century, lived the "terrible Baron des Adrets," who espoused the cause of the Huguenot king of Navarre, and who with one of his followers, Blacon, once a knight of Malta, and afterwards a freebooter, laid siege to Le Puy, and sacked the church of St.

Michel, but was defeated by the Catholics under the Count de la Tour Maubourg. Later on, the "terrible baron" and Blacon attacked La Chaise Dieu, mutilated all the statues and monuments in the church, and carried off the chandeliers, crosses, and vases. They also bore off a great statue of Moses, which they believed to be of solid gold. It turned out to be of copper-gilt; so Moses was most irreverently tossed headlong into a small lake, from which he was fished up again forty years afterwards. The ruins of the castle stand upon a conical hill of trachytic lava, which Mr. Scrope thought must have flowed from Mezen. These lavas should be compared with the tabular masses overlying the freshwater beds near Brives. Another fine ruin, in a romantic situation, within reach of Le Puy, is the castle of Bouzols, south-east of Mont d'Ours. In the Huguenot wars it was Catholic, or at all events was occupied by St. Vidal the Catholic Governor of Le Puy. Bouzols, Espailly, and Polignac leagued together; and M. Mandet, the historian of the civil wars of Le Velay, gives interesting descriptions of these feudal strongholds, and the way in which their lords taxed and levied contributions on the surrounding people without mercy. It was, it appears, owing to disagreement between Baron St. Vidal and the populace of Le Puy respecting the fortification of Bouzols that St. Vidal challenged Pierre de la Rodde to single combat, and was slain by a stab from his poignard.

The road to Bouzols from Le Puy is wild and peculiar, owing to the strange grouping of the hills capped with basalt, the excavated vales, isolated rock masses, and volcanic mountains away in the distance. The old Gaulish town of Monastier is situated on the borders of the great lava current of Mezen, while the castle of Bouzols stands on volcanic breccia similar to that of Corneille or Polignac, and rises in the middle of a great denudation of the freshwater and tertiary marls. It must have been a place of great strength, and with the light gleaming through its towers and loopholes is wild and weird enough. There are many local traditions about Bouzols, and a lady who was murdered by her cruel lord is said to haunt the place still. Below in the valley flows the Loire; and in front, to the south, rises the Lion de Coubon, a mass of basalt somewhat like a lion couchant. The basalt overlies a hill of freshwater marls, at the base of which is the village of Coubon. East of Bouzols is a valley of denudation in the freshwater strata, the valley of Lausonne, with lava streams overlying the hill platforms; while above these basaltic platforms rise the more recent volcanic cones of Prezailles and Freycenet. Another place particularly described by Mr. Scrope for its striking scenery and singular geology is on the Sumène river, a little north of Brives. Here we have the granitic rocks of Chaspinhac with its elevated vil-

lage, and these granitic rocks now separate the freshwater basin of Le Puy from that of Emblaves. The cone of volcanic scoriæ and cinders known as Mont Serre has been erupted on the edge of the granite escarpment; and the basaltic plateau, the Chauds de Fay, rests upon the freshwater beds. Here, too, are the Rochers de Peylencs, famous for their great blocks of olivine, specimens of which may be seen in the museum. This brecciated mass is very peculiar; surely the outburst must be local, and the blocks of olivine must have crystallized below the spot where they are now excavated. A great landslip has occurred, and let down masses of basalt, while the river Sumène rolls among a hurly-burly of *débris* and columnar ranges of basalt through a splendid gorge of rock and rushing waters.

The town of Le Puy is situated nearly in the centre of an area which was a large freshwater lake during portions of the Eocene and Miocene epochs. This ancient lake must have been at least twenty miles in length, by ten or twelve in breadth, and occupied a depression between hills of granitic gneiss; and probably the depression was caused by the subterranean movements preceding the great development of volcanic activity, which covered up the area occupied by the lake with lavas, breccias, and scoriæ. High granite hills must have risen all around; and there is little doubt that the granite peninsula of Chaspinhac which now divides the freshwater basins of Emblaves and Le Puy was a spur of high land jutting into what was in olden times a single lake. You might have sailed on its waters round by St. Paulien to Vaurey. It is probable that streams running from the same source as the present Loire and Allier flowed into the ancient lake; for it is evident, from old river drifts now elevated high upon hills where now no waters flow, that former rivers were compelled by land movements and volcanic eruptions to shift their courses over and over again. Our time was far too limited; and we only saw enough of Le Puy en Velay and its fossil remains to convince us that a series of events have occurred of magnitude and wonder, that are only yet foreshadowed to the geologist who searches for its past history, among silted-up lakes, ancient river beds, old granite hills, miles of lava torrents, and mountains of volcanic cinders and scoriæ.

From Le Puy to Vals.—There is a diligence from Le Puy through Pradelles to Langogne, a station on the Issoire Railway; but we strongly advise the geologist to make postal or other equine arrangements with our host at the Hôtel des Ambassadeurs at Le Puy, and avoid the diligence. Arrangements should be made also for horses to be sent on; for my companions, on a previous excursion a few months before, found that the best vehicle at Pradelles was a wretched "shanderadan," "and were dreadfully jolted over bonesetting roads."

We left at an early hour on a glorious September morning, and went along a steep road for several hours. When we had arrived at a height of about 1,000 feet above Le Puy, we saw a noble view of the surrounding country; but the basin of Le Puy was clothed in a dense fog, out of which the summits of Corneille and St. Michel towered like black island rocks. The great statue of the Virgin seemed to be looking over a still lake below; and the little church of St. Michel might have served for a lighthouse on a dark night for those who voyaged over its waters. Soon the sun dispersed the mist, and the scene was changed; the lake vanished, and was succeeded by a panorama of churches, houses, and the busy haunts of men.

The road the whole way to Pradelles passes over volcanic masses overlying granitic rocks, which are here and there exposed to view. We pass from the grapes and figs of Le Puy on to a wild sterile country, poorly cultivated, parts of which are heathy moorlands. Volcanic outbursts have been erupted through older sheets of basalts and lavas, all the way from Pradelles nearly to Brioude; but they have none of the characters of those of the Puys de Dôme in Auvergne—no craters, no modern lava streams running down the existing river valleys. This volcanic region appears to be of more ancient date than are the volcanos of the Puys de Dôme; everywhere the craters are degraded, and the ashes and scoriæ are spread about by denuding forces. There is one crater fairly preserved on the left, not far from the hamlet of Castaros, where we had sent on horses; but the grass covers the interior, and we saw no signs of a lava current having issued from its river or sides. Pradelles is a poor place and very dirty, so we recommend a halt at Peyrebelle in preference. The country round Pradelles is wild enough; and that it was once wilder appears from the fact that Mr. Scrope counted 150 volcanic cones about Prezailles to the N.E. of Pradelles. Before arriving at Peyrebelle, the house was pointed out to us where a dreadful series of murders were committed some forty years ago. The proprietor, Pierre Blanc, kept it as a roadside inn; and when he found out that any of his lodgers were possessed of money he murdered them in their sleep, and, with the aid of his wife and servant as accomplices, threw their bodies down a pipe into a large oven, where they were consumed. At last they were detected, and were all executed, close to the scene of the murders. The oven has been taken away, and the pipe built up; but the house still remains, and a dreary place it is. The hostel at Peyrebelle is rough, with the stable and cowsheds underneath the salon and sleeping apartments; but we found the landlady obliging and the cuisine excellent, and I should say that a geologist might make this his head-quarters for exploring the Mezen and the country round the sources of the Loire.

We are here on the plateau of Pradelles, which separates the Loire and the Allier, and within reach of many interesting localities and beautiful scenery; while to the fisherman it holds out the choice of many streams, full of goodly trout, within a walk—at least, so said our driver. Our road lay by La Chavade, along the flanks of the granite range on which rises the Loire. The whole scenery is changed as if by magic, and we find ourselves in a sub-Alpine district, among gorges and rocks and running waters. The road descends for seven or eight miles in a series of zigzags, and we had an opportunity of forming an idea of the disintegration of the granitic rocks from the wear and tear of atmospheric agents. The previous summer had been wet, and masses of granite had fallen from the mountains down the side of the gorge in heaps. At one place above the river the road had been carried away for many yards, and a large body of workmen were engaged in the repairs. We had to descend from our vehicle, and a day earlier our passage would have been impossible. Beyond this, fallen masses lay here and there in the road; so this route, after a storm, is not without danger. On our right was a river flowing far below, and across the valley rose granite hills—the source of the Allier —covered with the great forest of Bouzon, still the haunt of the wild boar and the wolf. Volcanic cones have in two or three places burst through the granitic district near the source of the Ardêche river, but have sent forth no lava streams into the valleys.

The people of Le Puy have a habit of altogether ignoring the existence of Vals, where there are several excellent hotels, especially the Hôtel des Bains, and of recommending the tourist to stop at *Thueys* for the Montpesat and Jaujac scenery, whereas Vals is only six or seven miles farther on. One line on the accommodation at Thueys in the summer of 1875, from the note-book of Sir William V. Guise, may be a warning to the tourist:—"But how to describe the so-called hotel! the dirt, the squalor, the smells of that most primitive of hostelries!" And then there was an "extortionate hostess," and all the while comfortable and cleanly Vals a few miles beyond. Still, Thueys is a place to visit from Vals, for it stands upon a great current of lava which has been poured from a volcanic cone east of the village. The columns of basalt are very grand, and nearly 150 feet in height. The river Ardêche has cut right through this basalt down to the granite below; and here, as in other localities in this country, we find the granitic rocks yielding much more easily to the flow of the waters than does the basalt. The river is now excavating the granite bank. The cone of Thuey is not far from the volcano of the Gravenne de Montpesat, but is much

smaller, and has no crater. Its lava flowed into the channel of the Ardèche on the south of the granite ridge, out of which it burst; while that of the Gravenne was erupted down the bed of the Fontaulier on the north of the ridge. In the summer the botanist should look for a good plant, *Nothochlæna maranæ*, which grows on the basalt above the sides; as also does *Spiranthes æstivalis*. *Carduus vivarensis* and *Cephalanthera rubra* were found here, as well as in the crater of Jaujac, in the summer months, by my friends Mr. John Kent and Mr. Elmes Steele, who botanized over this district in 1874. When we were there in the autumn the base of the hills was clothed with *Dianthus hirtus*, *prolifer*, and *superbus*; and from the same neighbourhood we gathered *Taraxacum gymnanthus*, *Chondrilla juncea*, and *Borkhausia fœtida*. We here saw the Camberwell Beauty (*Vanessa antiopa*) flitting along the great walls of columnar basalt above the river.

Vals is celebrated for its mineral springs. It lies in an amphitheatre of low wooded hills, and through the beautiful village flows the Volane stream, which is a tributary of the Ardèche. The source of the river Volane is among the granite mountains above Antraigues, and the most remarkable volcanic scenery in southern France. The time must come, when the railway is open from Montelimart to Aubenas, when Vals will be more frequented than any of the thermo-mineral sources of La Belle France. The mountain streams are full of fish, for they are but little fished; and we saw red-legged partridges and quail, and feasted on wild-boar hams from the forests on the mountains. The cuisine was excellent at the Hôtel des Bains, and the horses were strong and able. To the artist, geologist, and botanist the surrounding country is singularly attractive; indeed, it is extraordinary in more than one of its characteristics. The drive from Vals to Montpesat is about twelve miles, and is one of rare beauty and interest. We pass through the village of La Baume, which is itself quaint and interesting, and would serve as quarters for a few nights to those more active geologists who do not object to a little roughing. I would invite the attention of all geologists to a section on the right bank of the river, above the bridge at La Baume, and nearly opposite the ruined castle of Pourcheirolles. Here the columnar basalt, which runs like a vast wall by the river side, has been blown through by a "chimney" of volcanic ash and scoriæ, evidently of later date than the outpouring and consolidation of the basalts. Higher up the river the Baume basalts may be seen, overlain by an ancient river bed. Some time since I threw out the suggestion in "Nature" (No. 317, Vol. XIII.), that these volcanic outbursts and eruptions through basalts may have happened even in historic times; for the

Archbishop of Vienne, in the fifth century, mentions the occurrence of "frequent shocks of earthquakes," "fires often blazing," and "piled-up mounds of ashes," in this part of France. The geologist will see along the banks of the Ardêche and other streams an example of the power of swollen rivers in removing large masses of rock; indeed, nowhere have I seen better examples of transportation of rock masses by river floods than in this country. The ruins of a seignorial castle of Ventadour are grand as seen from the "chimney" just alluded to. The river bed has once been filled with a torrent of lava; but the victorious waters have again excavated a channel to the former level, and exposed the old river gravels, covered by the basalt. Hills of red cinders rise among the granite rocks, whose base is clothed with noble chestnut trees; and the peasant trains the vine on the sunny slopes, little mindful of the "ignes suppositos cineri doloso."

On the road to Montpesat is a small mineral spring called "Pestrui," which affords a sparkling chalybeate water, very refreshing and agreeable to the taste. Large hampers were being sent off filled with bottles of the "Pestrui eaux," considered excellent for gout and dyspepsia. Great quantities of the edible fungus *Boletus edulis* grew beneath the chestnut groves. The peasants of the country are well aware of its excellence, and consume it in great quantities. We had a large dish, garnished with fresh trout, at Montpesat, which would have been highly appreciated at the fungus foray of the Woolhope Club. The local name is "Ceps de Bourgogne." Here, too, we saw two or three specimens of a beautiful green Mantis, or praying insect, and, though late in the season, a good many butterflies. The "Gravenne of Montpesat" rises boldly on the left, with its red cinders, out of groves of chestnut trees and pines. The term "Gravenne" is derived from "gravier," or gravel, to which the loose cindery surface of the cone is not inaptly compared, and a neighbouring cone is called La Gravenne de Souillols. The crater from which the mass of scoriæ and cinders which covers the side of the cone have been erupted lies on the side immediately above Montpesat, and the surface of the cone is strewn with granitic *débris* blown out of the crater during eruptions. A lava stream has poured into the bed of the Fontaulier, which, below the ruined castle of Pourcheirolles, meets another lava stream coming down the bed of the Pourseille. The summit commands a grand view of granite mountains, profoundly scored in deep gullies, with volcanic cones rising abruptly from their flanks. No word-painting can do justice to the scene selected by Mr. Scrope for this admirable illustration of the "Valley of Montpesat" (Pl. XIV.) in his "Volcanoes of Central France." The position of

the ruined castle as seen a little below Mr. Scrope's sketch, and from the river, is quite startling, so grand and picturesque is the surrounding scenery. The river runs through dark frowning cliffs of columnar basalt, above which rise green groves of chestnut trees, and on the left the red volcano of Gravenne. Then in front stand the ruins of the old castle, rising sternly from what appears to be an island of basalt, but which is really a peninsula excavated by rivers which flow on either side. Then high above all rise white granite mountains, so white here and there that you may fancy them capped with snow; and behind all and above all, the bright blue sky of the south of France. So wonderful is the colouring of this scene, that Sir W. Guise was occupied for hours, and came away dissatisfied. I remarked here, as well as at La Baume, that the basaltic lavas had been shifted in places by later volcanic outbursts—attempts to establish a volcano, but which have failed sometimes even to form a "chimney." We cross to Montpesat by a good bridge, and the sections on the two rivers, as seen from the castle, are very fine. The castle is perched on the extreme end of a peninsula of basalt, the point of junction of two rivers, the channels of which had been filled with torrents of lava, but through which the rushing mountain streams have again cut their way down to their former level, through the old excavated granite.

The Pourseille lava stream was erupted from a volcanic cone, up a valley in the mountains behind the village—a wild hill walk, which leads to Burzet and the sources of the Loire.

We were told that wolves were so abundant around Burzet during the war between France and Germany as to have become an absolute nuisance to the inhabitants of the mountain villages. It was supposed that they migrated from other parts of France, and had taken refuge in the forests of the Ardêche. Several children were destroyed during the winter months. Of the habits of the wild boar the people appear to know very little excepting that they were best to eat when fattened upon chestnuts. Chestnuts are here distinguished as "marrons" and "châtaignes," the "marrons" being the finer. Sir William Guise's list of summer plants includes *Silene rupestris*, *Scleranthus annuus*, *Cephalanthera rubra*, and *Dianthus cæsius*.

The expedition to Jaujac should be made so as to see both routes, viz. the one by the valley of Carboniferous rocks enclosed in a granitic hollow, and the return journey by the valley of the Alignon to La Baume. We quit the Vals and La Baume road about six kilometres short of La Baume, at a point called Les Mines de Prades. Coal has been worked here, but does not appear to be of much economical value, as might be expected from its position. The strata are highly inclined, and without doubt are much crushed and dislocated. The cone of Jaujac, called "La

Coupe de Jaujac," has been erupted through the coal measure rocks, and has a large and perfect crater covered now with chestnut trees, but within which grow several good plants, such as *Dianthus cæsius*, *Cephalanthera rubra*, and *Convolvulus cantabricus*. *Silene saxifraga* grows on rocks in the bed of the Alignon.

The village of Jaujac stands upon the lava torrent which came down from the crater, dammed up the river Alignon, and for a time formed a lake above. We were there on a Sunday; and the people were all dressed in their best, the women at mass, and the men smoking and playing dominoes in the inns. The vineyards on the slopes of the hills between Jaujac and Thueys were clustered with grapes, which were being gathered, and a well-dressed woman presented me with as many as I could bring away. Here we met a priest, who addressed us on the geology of the district, and who knew Mr. Scrope and M. Elie de Beaumont apparently better than he did the geology of his own country. The walls of columnar basalt at Jaujac are very striking, and are seen in contact with the old land surface over which the lava flowed. Very different, too, is the quality of the land since the overflow by the basalt. The decomposition of the lava plateau forms a rich generous soil on which grow the mulberry and the fig. The granite is sterile enough, and requires constant aid from manures. Walking for some distance down the river, we could see that the thickness of the basalt could not be less than 100 feet, and we observed that, in passing over bosses of granitic rock the lava had crystallized in prisms at right angles to the inclination of the surface over which the lava flowed. In this splendid river section three points of geological interest are clearly to be seen. First the river Alignon flowed in a channel between granitic and Carboniferous rocks as deeply as it does at present; then came the outbursts from the Coupe de Jaujac, which filled the old river bed with lava and dammed the river; then the river flowed over the basaltic plateau, and since that has cut its way down through 100 feet of solid lava to its present level. On the left bank of the river below the bridge there is a corner below the hill before ascending the pathway to Thueys which looks like a young "chimney," for the basalt is partially dislocated, and there is a little outburst of volcanic sand. Below the village of Nerac prismatic columns of lava may be seen resting on the rolled pebbles of the old river bed.

We went to Antraigues for the Coupe d'Eyzac, distant about five miles from Vals. The road follows the course of the Volane river through a romantic gorge, which leads up to the granite mountains of the Haute Vivarais. This valley differs from the others, inasmuch as the basalts appear to have been

more denuded, for they are seen in patches of columnar lava, clinging, as it were, to sides of granite. The shingle of the old river bed is seen in one or two localities on the right bank overlying basalt, and at an elevation of 80 or 100 feet above the present stream. The village of Antraigues is very picturesque, situated on a lofty rock, at the foot of which flows the Volane in a deep rocky channel. On the path leading up to the village stands an isolated rock, about 30 feet high, of twisted basaltic columns, resting on granite. This rock is a most remarkable monument of the denuding powers of atmospheric in-



"Le Pain de Fromage" (sketched by Sir W. V. Guise, Bart.).

fluences. It is evident that the basalt had flowed into a fissure in the granite, and that the granite walls have since been denuded. It is known by the name of "Le Pain de Fromage." The crater of the Coupe is broken down on one side; but the hill well repays the ascent, for the view commands the Coiron range, and we can see the capping of basalt from the point where it was poured out from the granitic base near Le Gua, to flow away in the direction of Privas, where it covers Jurassic and Cretaceous rocks, in widely-spread plateaux. On the other side

Aubenas glistened in the sun, and we thought we saw the Alps of Dauphiné dimly through the haze.

Aubenas is situated on a lofty eminence above the Ardêche, which flows far below, and is crossed by a stone bridge. The prospect from the parapet in front of the great square is wonderfully extensive, diversified as it is with woods, villages, and cultivation; the Coiron range, capped by basalt, just opposite, and lofty granite mountains rising to the north. The brown old town has quite a mediæval aspect, and from its situation must in olden times have been a stronghold. The Hôtel de l'Union is the best, but very inferior to the hotels at Vals. There are, however, diligences from Aubenas to all parts of the surrounding country, so that the geologist may easily start by one of them at an early hour in the morning, and walk back. The opening of the railway to Montélimar will much facilitate the exploration of this country by naturalists. On the right of the road in ascending to Aubenas we see sections of Jurassic rocks. These rocks are of Liassic age I believe, but we saw no fossils. They are traversed by a dike of augitic greenstone which forms the summit of the hill.

From Aubenas to Montélimar the scenery changes altogether; and nothing can be more different than is this drive as compared with the scenery of Jaujac and Montpesat, yet most interesting to the geologist. There is a grand section of Jurassic strata across the Ardêche, very similar in mineralogical appearance to the Lima beds of the Lias; and, as the ascent is of long duration, we had several opportunities of [illegible] for fossils, but found none.

[illegible]en Aubenas and Villeneuve de Bere, we had an oppor[illegible] of observing the way in which masses of basalt strewed [illegible]lains; every wall is built of them. This *débris* is a relic [illegible]e denudation and degradation of the escarpments of the Coiron hills wearing backwards. Beyond Villeneuve we have fine views of the great headlands of the Coiron mountains, and their dark cappings of basalt, the source of which we longed to investigate from Vals, but were prevented. Mr. Scrope believed that these basaltic currents flowed from the Mezen; but there are one or two objections to that idea. There is no basalt whatever overlying the granite for several miles, between a place called Le Gua, north of Antraigues, and the volcanic eruptions near the sources of the Loire. Again, Mr. Scrope mentions that the well-known land-shell, *Cyclostoma elegans*, has been found in old land surfaces underneath the Coiron basalts. This does not look as if the Coiron basalts were as old as those of the Mezen. Be this as it may, the geologist cannot fail to be struck with the lapse of time indicated by the erosion of vast masses of strata, the effects of frosts and snows, rains and rivers, since the basalt

of Coiron flowed over a great plain of secondary rocks, which abutted against the granite, and protected it from denudation. Since that period great valleys have been excavated, and the configuration of the country has been entirely changed. We saw in several places the excavations of the railway from Montélimar and gathered on the limestone *Centauarea cærulescens* and *aspera*, *Æchinops libro*, and *Campanula media*. Leaving on our right the ancient city of the Helvii, Aps, our last view of volcanic rocks was the Roche Maure, which in 1751 led MM. Guettard and Malesherbes to the discovery of the volcanos of Auvergne. What changes have happened since those days; what progress in geological knowledge! The "Principles of Geology" had not been penned, and the tertiary shells of the Apennines were supposed to be the scallops of the pilgrim. It was dangerous to doubt the fact of a universal deluge, or that the world was more ancient than some 6,000 years. The older rocks were but a chaos, and no Lyell, Sedgwick, or Murchison had appeared to throw the vigour of a lifetime into a labour of love. Yet the investigations of the geologist are inexhaustible; and among hills and valleys the most romantic, in beautiful southern France, where the wild rose blossoms on the red cinder of the volcanos, and chestnut forests cluster at their base, there are problems to be solved, and shrouded fossils to be disinterred, which shall yet throw light upon the extinct volcanos of the Ardêche.

FLINT IMPLEMENTS.

By Captain C. COOPER KING, F.G.S.

[PLATE IX.]

THE study of prehistoric archæology, though comparatively one of modern origin, has made rapid strides towards systematic development and classification during recent years. The probable chronology of the earlier races of mankind has been so far examined as to admit of the definite grouping or arrangement of their relics into periods of greater or less duration, and of more or less defined limits. Thus it has been recognized, after much controversy, that the drift gravels of river valleys, and many caves and rock shelters, contain stone implements coeval with the remains of the Mammoth, Rhinoceros, Cave Bear and other animals long since extinct. These, of which the St. Acheul specimens offer the best known examples, have been denominated Palæolithic implements—rough chipped tools of old time. Next to them in order have been placed implements of higher art; those of polished stone, of the Neolithic age. After this came the bronze period, when metal took the place of stone; and this was soon followed by the age of iron, the first days of which overlapped that of bronze. Its early dawn was prehistoric, its ripe manhood modern. And so rapid was human progress when the metal more difficult to work, and requiring more skill in its manipulation, began at last to be generally used for warlike and domestic purposes, that the iron man soon ceased to have no other records than those of the implements he manufactured. Iron man soon ceased to be prehistoric.

But there are other relics of human handiwork, less definite than those of the three great ages, into which early human history has been divided. These may be classed as "surface finds;" for they are the probable result of merely temporary occupation of certain sites for brief periods of time, and may belong to any age. The amount of skill evidenced by the rough remains found in these cases is the only guide as to their antiquity; though even then the degree of excellence is not a

certain test, for some tribes may have been more able than others in the manufacture of temporary tools. No highly artistic weapons are to be found as a rule there, for the wandering families would retain with them their more valuable implements; and these ancient camping grounds were occupied apparently only for the brief halts necessary for rest and repose, so that the duration of the stay would be too brief to admit of much careful work.

Polishing and skilful finishing of tools is the result of time and continuous labour. Even if better implements of bronze, or iron, or polished stone were carried by a nomad tribe, these would be all too valuable, too precious, to be used for the ordinary occupations of life. "Surface finds" may belong to the Neolithic, bronze, or even iron ages; for the travelling bands or families halting for the night at some favoured place would be able, in most localities, to find rough flints, out of which rough flakes for knives, rough tools for work, rough "strike-a-lights" for fires might easily be made. If there were any doubt in the mind of the head of the household, a very few flint stones carried by the women or children thereof, would enable the necessary implements to be fashioned when the camp was pitched. So that scattered in patches over vast areas of country, on the old lines of road or communication, the sites of old camp fires may be marked by flint-chips and even rough implements.

In the southern part of the valley of the Thames, between the river itself and the Guildford hills on the one side, and the two great cities of Londinium and Silchester (both prehistoric sites of occupation, one being the capital the other the centre of tribute of South-eastern England in Roman times), on the other the traces of successive occupation are common. In the valley of the Thames are remains of animals, long since extinct, buried in gravel beds marking different levels of the river. Elephant and cave bear, hyena, and the great *Bos primigenius* drank of its waters in old time. In its higher-level gravels have been found, in places, true Palæolithic implements. Over this area, crossed as it is by Roman roads, marking old lines of communication, prehistoric tribes, tribes of Saxons, and Roman legions have passed and left their trace.

Upon Easthampstead plain is a tumulus that contained implements of polished stone and rough pottery. On the Hartford Bridge flats is another. Near it was found a fine polished celt, now in the possession of Mr. Raikes Currie. At Wickham bushes, near Broadmoor Asylum, are fragments of old tiling, old pottery of Romano-British or Saxon work. On the road between York Town and Frimley, at the foot of Prance Hill, were dug out at a few feet below the surface, Romano-British cinerary urns. In the gravel of Reading, at the junction

of the Thames and Kennet, some twelve feet down, was discovered a Saxon javelin of iron, the relic of an iron age, that of invasion and thirst for conquest. The barren flats of the Eastern and South-eastern highlands of England abound in such history. On the great Roman road between Silchester and Windsor was found a Roman statue now in Mr. Waterer's garden, at Bagshot, through which the road ran. And over this land, so often traversed by successive races, "surface finds" are common. Near the Staff College in the Wishmoor Valley, farther down the banks of the rivulet that drains it, all along the slopes of the Hog's Back, near Guildford, by which the great line of traffic from Southampton to London and Canterbury was carried, "surface finds" in perfectly defined patches are to be found by those who seek.

Now what are the signs of the existence of an early race?

First of all we must remember that, speaking very generally, the old lines of traffic are used still. Newer ones may have been made since, as forests were cleared, morasses drained, and rivers bridged; but the old roads leading to fords that existed then and exist now, old road lines occupying the dry high lands over the ill drained low lands, still mark lines of intercommunication.

Modern sites of occupation are frequently old ones too. Our ancient village churches indicate old centres of habitation where British villages or pit dwellings once existed.

Our first requirement, then, is the old line of traffic or trade.

Next reduce ourselves to the condition of a savage. Assume for a moment we had no house or shelter, no utensils of any size to carry water, the roughest of coverings for the feet, the most primitive garments for the body. Where should we seek to camp under these unpleasant circumstances? On dry land near water firstly. Out of the cut of the east wind, under the shelter of a hill or wood next. Human nature was much the same then as it is now. Such comfort as those early days could give would certainly be sought for.

And so we find the local habitations of prehistoric man. Mere surface collections of broken flints; but still they are broken with intent, and the flakes are numerous, and similar in character. Even more than that, they are in purely local groups.

Enter a large field that may seem to be promising and to fulfil all the conditions required. It may be full of broken flints, plenty of questionable fragments may lie near you; but it is probably only in one small area, such as the circuit of a camp fire, that abundant traces of human work may be found. Generally they were mere halting places on the line of march. Rarely on the road itself, but, as a rule, under shelter from weather and away from the track on which, at night, marauders might be on the watch.

By the side of the camp fire the old Archaic man repointed (that is re-chipped) his axes and refashioned his arrow-heads. Sometimes the flint broke unkindly, and it was flung aside as a broken knife would be.

As an American would whittle a chip, as a boy amuses himself by carving a boat out of a block of wood, to pass the dull evenings of winter, so, we can well imagine, the Archaic boy, copying his elders, learnt on his own account to chip and fashion flints. The evening meal had to be cooked and the "strike-a-light" came into requisition, to be cast aside when done with, for any other piece of flint at the next halting-place would do as well. And remember his materials for fire-making were very simple. A piece of iron pyrites, some vegetable fibre, and a flint stone. It must have often taken a long time to get a light in damp weather. Many chips must have been knocked off uselessly with cold hands and such rough material.

No wonder, then, that "briquets" are numerous and are much worn. But the meat had to be cut, the bones well scraped, perhaps even the finer ones converted into needles, or arrow-heads, and for this longer flakes would be required.

So from larger blocks long sharp-edged flakes were struck off and used. Some of these rough blocks, when so denuded, were sharp enough for blunt chisels; others could be made so by breaking them across at a sharp angle, like a rough mortice chisel, as Dr. Gillespie has suggested. With these, stakes burnt in the fire could be roughly shaped down to a point to form stockades, &c. When the occupation of the site lasted for any time it may have been thus protected with stakes and wattle.

Remember there was no iron to dig with; only sharp-edged stone to use for cutting purposes. Then skins had to be dressed down, scraped with a thumb-shaped flint which would rub and not pierce or cut them. Needles were wanted and were shaped from fragments or splinters of the bones of rabbits and birds by flint flakes, and the eyes bored with a small pointed tool.

All these operations would be the natural outcome of natural necessity; and it therefore follows that to seek with comparative certainty for traces of early man, the following conditions must be, as a rule, fulfilled: 1. Occupation sites, more or less permanent, are to be looked for near the older roadways leading to fords or ancient bridges, their outline being, though now marked by hedgerows, as devious and winding as the ancient track was. 2. Sheltered spots near these roads, protected from view by trees, and comparatively dry though still close to water (especially if the sites be likely to afford food supplies of roots or rabbits) are necessary. 3. The ancient names of places are often a valuable guide. All old camping-grounds being near water, the different equivalents for water in local names may

point to their position. As the Rev. Charles Kerry has stated, the names for or appertaining to liquids, are themselves liquid. Water, Ooze, Ouse (a river) Oasis, Well, Wet, all have *u*, *o*, or *w* as their prefix. Even the Saxon Wan has the same liquid sound. Thus Wanborough, "the hill by the marsh"; Wishmoor, the Uisk-moor, the water-moor or possibly the big drinking water (Celtic); and similar names would indicate, as they generally do, probable camping-grounds.

It does not follow that, whenever these three conditions are fulfilled, flint flakes, or occupation signs, will be as a matter of course discovered, any more than, when an excellent site for building is pointed out, one invariably expects to find a house there.

All that can be said is, that flakes, &c., are never found in places that do not fulfil these conditions more or less. Take the neighbourhood of Aldershot, for example. Near the Staff College by the "Wishmoor" stream, sheltered by the Easthampstead ridges, near the old tracks still existent, converging on the rare fords of the river Blackwater, was a definite "station." Lower down the rivulet, on a dry sandy peninsula, once washed on two sides by its waters, was another equally clear—not *on* the road, but *off* it; not in the way of enemies, but concealed from them by trees or hills.

On both sides of the Hog's Back, about Guildford, at the outcome of the streams, close to the ancient villages of Seale, Farnham, Puttenham, and the old manor of "Wanborough," the traces of early peoples lie thick in the flint flakes and tools that extend over certain limited areas there. Even the soil in these same areas is darker from occupation, and Mr. Kerry has found this sudden local alteration of colour to be a nearly infallible indication of primæval camps.

At Bob's Mount, near Reading, on dry land overlooking the erstwhile marshy valley of the Kennet, seemed a probable site, being near water, and having a corrupted ancient name. Search at once revealed numerous flakes and cores. Excavation at one point resulted in the exhuming of a Roman amphora. It had been for generations evidently an ancient halting-place. At Odiham, as will be seen by a glance at the map, are the springs and sources of one of the tributaries of the Loddon: near it is the village of "Wanborough," and the relics of a mediæval castle. Of course there were implements and flakes there, for everything pointed to old occupation. A main road to Basingstoke, an ancient name, abundant water springs. Primitive man had used it; Saxons had left their traces there; the Normans had seen its value, and had built a keep that checked the army of the Dauphin of France, and held prisoner the Bruce.

But what have the ancient people left behind them in these

places? They are indicated in Pl. IX. First and foremost are the cores from which the flakes have been struck. These are vertical, merely for making flakes; pyramidal for the same purpose or to be used as wedges and even rough heavy scrapers; some of the former pattern seem to have been definitely fashioned for smoothing down stakes for stockades or spear-shafts, the ends of which may have been previously charred by fire. The ends are left round so as to be held in the hand, or pointed to fit into a socket, but the other extremity is, as Dr. Gillespie first noticed, again broken across by a sharp blow at an almost constant angle, and the edge here bears marks of wear. In his paper read before the Anthropological Institute he says that in this form, commonly known as the "hoof core," the angle was exceedingly constant at 70°. "Out of the 100 cores which I examined 12 were double-ended, 35 were bevelled at an angle of 70° as near as possible, 10 at 75°, 24 at 80°, 9 at 65°, 5 at 60°." Thus cores for flakes, and "hoof cores" for tools, are always to be found. Then there are the flakes themselves. These are generally triangular in section, often rhomboidal. The sides bear marks of wear; the ends are often rounded as "thumb scrapers" to dress skins, pointed for boring holes, or to be used as rimers, or notched for finishing bone needles or completing arrow and spear shafts. But there are numerous fragments too. Some are rough bits knocked off in getting the flat table-end to a block of flint, whence long flakes were to be knapped. Others dressed roughly on all sides, without apparent intention, except to render them somewhat circular, may have been "throw stones," or sling stones. But a most common type of all is the "briquet," or "strike-a-light." They can be recognised at once by their similarity of shape, and by the equally similar marks of wear to those on the ordinary smoker's stone of his flint and steel. Rough sometimes on all sides but one; but on that the edge is chipped into a rounded form, on which there is much minute scalloping. They are thicker than the ordinary flake, are smaller generally, are roughly round, oval, or square, but always with one flat side and one even edge. Lastly there is the implement itself, the stone-chipped celt. These are naturally of a higher degree of art. They have not, as a rule, been made in the place where they were found, but have been brought there by their former owners, as the nature and character of the flint will tell. But they, like all tools, have worn by use. Repointing his axe by the evening fire, primitive man has often made a false stroke and broken or damaged his stone weapon. If in his opinion useless it was thrown aside like a broken knife, so that the axes found in these places are always well worn and damaged by an attempt at repair. It is the same with the arrow-heads. They are much used, and having lost their sharp-

ness and point are too small to re-chip. The useless barb, like a broken needle, was thrown aside. All these things may be expected, and most are found on the sites of the "surface finds."

Now they are rarely discovered in any number, strangely enough, in the old earthen entrenchments, or so-called Cæsar's Camps," of southern England, and there seems to be a sufficient reason for it. These occupy lofty sites, good posts of vantage for defence and observation, but the water supply must be faulty; the exposure is certainly unquestionable.

Fancy Archaic man, shivering in his coat of skins, on the top of one of these fortified hills, with the bottom of the neighbouring valley to go to for a draught of water.

These great entrenchments, which are certainly not Roman, and may well be deemed prehistoric, would have a much greater *raison d'être* if we imagine them to be the keeps or citadels of the neighbouring villages, to which, as in feudal times, all could go, flocks and herds, women and children, when danger threatened. Flakes would be rare there, then. There would be little time for peaceful amusements. The camp fire would be surrounded by anxious faces, too interested in outside matters to indulge in play.

Most of them are places of temporary, not permanent, occupation, and hence it is that relics are rare; for few of the entrenchments have good water-supply, and flocks, herds, and people would soon exhaust it, and render a speedy return to the watercourses absolutely necessary. The tribes did not live there, but only took temporary shelter, and this need have been brief, for even the assailants must disperse in search of food, and in all probability if the first attack failed they withdrew.

Where the fortifications surrounded actual village sites the conditions would be different, and the usual discoveries might be made; but the camps on lofty hills could not have been as a rule held for a lengthened period. The quantity of implements found in the Cisbury Camp need offer no exception to the rule, for the entrenchments were built on the pre-existing site of old quarries where flint had been dug for tools.

No traces can be found in surface-finds of actual dwellings, nor of the exact way in which the tools were held or hafted. But some ancient weapons have been found in other places with the old handle still fixed to them. Modern savage life again furnishes another clue. They were generally inserted in a cleft stick, sometimes vertically as a spear, at others in a curved branch, like an adze or pick. Doubtless withes, or strips of skins—the latter especially, as if tied wet they would shrink and tighten up the tool—were commonly used, and even in modern weapons there is an indication that such was really the case. Malay

creases often have in the metal at the base of the blade the mark or cast of the cord which fastened earlier weapons to the handle. What was once a necessity has become merely an ornament, and the survival of the idea is all that is left of the more ancient plan. Powerful weapons they were in the hands of a strong man. Heavy blows could be struck for offence and defence. From the Lincolnshire Fens came the skull of an ancient Bos pierced through the frontal bone by the stone axe of primitive man.

It is not difficult to distinguish between the true marks of wear and those produced by accident; nor need the chance fracture of a stone into a shape resembling the true relics be confused with the ancient tool. All real flakes, struck with intent, have one flat side marked by a rounded bulb at the end, the other sides being more or less numerous, though as a rule the section is triangular. When these have been used for scraping, either from right to left, or *vice versa*, the natural tendency of the operation would be to break off small fragments on one side of the used edge, leaving the other still unchipped. Accidental crushing would certainly be likely to create fine chipping or shelling on both sides of it. Intentional work rarely can leave traces on more than one side.

So with the implements. A true edge to a tool fashioned from material that breaks with a conchoidal fracture could only be produced by blows struck alternately on either side, thus forming a series of alternate scallops, giving a wavy edge. If the concavities were opposite to one another, as they generally are in accidental forms, and in by far the greater number of forgeries, a blunt crushed edge, incapable of cutting, would alone be made. All true flint workers, and notoriously those of old time, have recognized this. Nature's processes rarely conduce to a similar result; her work is nearly always irregular, but man's labours are characterized by regularity, and have a definite intention about them.

Nature, the grand instructress, will furnish a handful of useful though inferior tools from any gravel-heap or pile of *débris*. She can make implements, and make them very badly, too. No two of them are alike. None quite the thing. Human art and thought can alone produce similarity of workmanship. Nature may clumsily provide stones that could be used as weapons, but she does not make many, and even they are clumsy. Nature can fashion, or wear, or weather a rough rock pinnacle into the feeble semblance of a human face or form. Human art and intellect can see in and produce from the living rock the noble statue, or the speaking bust. Nature never shows us two flowers exactly alike. Art can give facsimiles of any given type of human handiwork, for in the results of man's skill there

is always a definite similarity. Old sub-angular flints and tools, again, have a well-defined lustre or patina due to alteration of the surface, and this peculiar appearance is difficult, if not impossible, to produce. Given, therefore, a stone shaped by bold chipping into an axe-like shape, with a wavy edge, shining with a tint unlike that of a freshly-broken stone among the relics of a surface-find, and it may be classed undoubtedly as a human tool.

But what, it is often asked, is the use of a study the materials for which are rare, the deductions from them so problematical? Now nothing could be more injudicious than to attempt to gauge the value of any knowledge by the results of the work done in one generation. Human life is too short for men to do more than further little by little the work of the preceding time, regardless, as a rule, whether their contribution to knowledge is worth preserving or not. Posterity will be the best judge of that. The philosopher who first applied two different pieces of metal to the leg of a frog and noticed that the muscles moved, scarcely foresaw that from that insignificant experiment would come the science of electricity and the shilling telegraph. When James Watt, pressing the lid of his aunt's teapot, found that steam had lifting power, he probably did not dream that from the development of the fact would come steam-ships that would move against wind and tide, and railways with engines that could travel at the rate of sixty miles an hour.

The old alchemists who, in their search after an imaginary philosopher's stone, discovered many a previously unknown chemical combination, many a hidden secret of nature's laboratory, did not imagine that the practical result of labour they then regarded as useless would be a better system of medicine, a more extended usefulness in the arts.

They worked for their own time, satisfied to do the work that pleased them best well, and left to future generations to accept what was good and reject what was bad in it. So with this study, one yet in its infancy even now. The most interesting study of mankind is man. All history is useful as teaching us lessons of what has gone before. Here we have traces of very ancient history indeed. Weak as the traces are they tell something of man's early habits before written records took the place of stone.

Then, again, even the value of a study should not always be measured even by its practical usefulness. In that charming book which all boys either have, or should have, read, "Evenings at Home," there is a story entitled "Eyes and no Eyes." It tells how two lads went in different directions for a walk and one returned with body exercised, it is true, but with mind unrested by the only rest mind can have—change of

thought; the other has seen the beauty of the flowers, the habits of the birds, the great glorious picture that grand old Nature opens to those who love her. Which is best or even most practical? To have a pursuit, even if it be but the study of flint chips, or have no other resource than that dreariest of all dull things, a mere "constitutional" walk. Average eyes by research and examination become comparatively microscopic in their power, and in seeking or searching for analogy between flint tools we may learn to understand better the shape and form and usefulness of other things too. Eye-training is mind-training also, for they must work together; and our woods and barren hill-tops, our valleys and plains have a fresh interest and a fresh light thrown on them if there can be found traces of human occupation to show that others, too, had loved them, others too, had seen their beauty before Greek or Roman had got beyond the age of Neolithic man. "The mind like a knife quickly rusts if not used. Unless the eye is trained to see, it becomes dim; unless the ear is trained to hear, it gets dulled; and this is why so many, careless to sharpen their wits on the whetstone of outlook and thought, enter into life and pass away from it, never knowing in what a world of beauty, bounty, and wonder they have lived."

Lastly one study so leads to another. An examination of the surface of the ground would lead most people to wonder what there was beneath it. The stone axe driven firmly into the head of a *Bos primigenius*, such as was found in the Lincoln Fens, must direct attention to the question of how the skull was deposited where it was found, and what were the physical conditions of the world in old time. Prehistoric archæology and geology are so closely allied as to be in some cases inseparable. Is geology of no importance? Can any knowledge of this grand universe around be considered valueless? What is good and vital and useful in any study will live; what is of no value will pass away like last year's flowers, which, useless as they seemingly were, gave pleasure and interest to some in their brief existence. Longfellow once wrote of a man of great scientific knowledge and repute—

> Nature, the old nurse, took
> The child upon her knee,
> Saying, "Here is a story-book
> Thy father has written for thee."
>
> "Come wander with me," she said,
> Into regions yet untrod,
> And read what is still unread
> In the manuscripts of God."

And he wandered away and away
With Nature, the dear old nurse,
Who sang to him night and day
The rhymes of the universe.

And whenever the way seemed long,
Or his heart began to fail,
She would sing a more wonderful song,
Or tell a more marvellous tale.

EXPLANATION OF PLATE IX.

The plate is designed to show the set of things that may always, or nearly always, be collected at the temporary halting-places of early races of mankind. They consist of implements (*a*) with a true wavy, and therefore cutting edge, very different from the similarly shaped stone (*b*) which has a crushed edge, and is therefore either a forgery or has been the result of accidental and not intentional shaping. The flakes (*c*) may either be triangular or rhomboidal in section, and, like these two, unworn, having been merely knocked off in fashioning a tool. But they may on the other hand have been used for work, and then the marks of true wear (*d*) will be distinguished from the "crush" wear (*e*) by being on one side of the edge rather than on both. The cores may be of different shapes (as *f*, *g*, *h*, *i*), while those with lower angles, produced as in the "hoof" cores (*h*), or (*i*) by striking off a fragment of flint after the core has been made roughly cylindrical, frequently bear marks of wear as if they had been employed as rough chisels. The briquets (*k*), or strike-a-lights, are thick oval pieces of flint, with one edge worked somewhat round, and one side nearly flat. It is on this, that the material used as tinder is held. Some of the irregular pieces (*l*) have a rough cutting edge on one side only, the other being left round so as to be held in the hand, while many flakes are worked for special purposes, such as long "thumb scrapers" for skin-dressing (*m*), notched scrapers (*n*) for arrow-fashioning, piercers or rimers (*o*) for making the eyes in bone needles, and circular scrapers (*p*), which are large oval pieces of flint much thinner than a briquet, but bearing marks of wear all round. There is not much difference between these two forms, save that the scraper being thinner is better calculated for the work.

THE SONG OF THE CICADA.

By JOHN C. GALTON, M.A., F.L.S.

[PLATE X.]

> "Sussen Fruhlings susser Bote!
> Ja, dich lieben alle Musen,
> Phobus selber muss dich lieben,
> Gaben dir die Silberstimme."—GOETHE. From *Anacreon*.

> "The Cicada, people of the pine,
> Making their summer life one ceaseless song."—BYRON.

THE song of the Cicada* has been familiar to man from the most ancient times. Among the Greeks this insect was the object of a veritable "cultus," and for the enjoyment of its song it was imprisoned in a cage, just as are the song-birds of more modern times.† A Cicada sitting upon a harp was the emblem of the science of music; for the story goes that when the two rival musicians Eunomus and Ariston were contending upon the harp for a prize, a Cicada, flying to the former and perching upon his instrument, supplied by its voice the place of a broken string, and thus secured to him the victory.‡ Anacreon

* The Latin name *cicada* is derived, according to Beckmann, from the word *cicum* or *ciccum*, "a thin skin," and ᾄδειν, signifying a sound produced by the motion of a pellicle. Others derive it from the Latin words *cito cadat*, implying that the insect soon vanishes, is short-lived. Westwood's "Classification of Insects," Vol. ii. p. 421.

† Such is still the custom in China. This can hardly, however, be accepted as a criterion of musical taste.

‡ "Kirby and Spence's Entomology," Vol. ii. p. 403. Winckelmann, however, the celebrated German art critic, makes the statement ("Versuch einer Allegorie," Werke, Band II. s. 529), that an indifferent bard was symbolized by a Cicada. This, however, he appears further on (Ibid. s. 548) to contradict by saying that Music is represented upon coins of the Messenians in Arcadia, where, according to the testimony of Polybius, it was practised more than among all the Greeks, by the same insect. In an editorial foot-

has dedicated to this insect one of his most charming odes.* He there exalts its melodious voice, reverences it as the sweet harbinger of summer, calls it the "friend of the Muses," and, finally, places it in the rank of the gods.

The Latins were far from sharing in this Greek enthusiasm, for Virgil † accuses it of bursting the bushes with its harsh and deafening song:

> Et cantu querulæ rumpent arbusta Cicadæ.

In the South of France its song is held in but slight esteem. As for the northern provinces, they do not even know it, for they mistake for its music the cry of the large green grasshopper. This error has been committed by the great French fabulist La Fontaine, who speaks of the Cigale as chanting *all the summer, day and night.* The artist, moreover, has drawn a grasshopper to illustrate the first fable of this celebrated humourist.

Leaving now the domain of imagination and poetry for that of prosaic fact, we will direct our attention to the mechanism of the cry of the Cicada, be this regarded as musical or the reverse. Aristotle knew that the musical organ of this insect lay in the abdomen, and that it was, moreover, peculiar to the male sex.‡ The latter fact, too, was familiar to the poet Xenarchus of Rhodes, for he sang, in not very gallant strain:

> Happy the Cicadas' lives,
> Since they all have voiceless wives.§

But to the naturalist Réaumur must be conceded the honour of discovering the sound-producing organ, the drum—"la timbale."‖ Unfortunately, this illustrious observer was not able to dissect living Cicadæ, and his attention—directed to a funda-

note to the first-quoted passage, it is further stated that upon a vase of baked earth in the rich collection of the family Vivenzio, in Nola, there is the humorous representation of a poet placing in the flickering flame of an altar his lyre, from the strings of which some Cicadæ are springing.

"According to Plato the Muses transformed into Cicadæ the men who amused themselves by singing, and were so absorbed in that occupation they forgot to eat and to drink." De Gubernatis, "Zoological Mythology," vol. ii. p. 223. London, 1872.

* Ode LXIII: "Εἰς τέττιγα." This has been beautifully rendered by Goethe.

† Georg. III. 328.

‡ "Οἱ τέττιγες. Πάντα δὲ ταῦτα ψοφεῖ τῷ ὑμένι τῷ ὑπὸ τὸ ὑπόζωμα, ὅσων διῄρηται, οἷον τῶν τεττίγων τι γένος τῇ τρίψει τοῦ πνεύματος." "De Animalium Historia," Lib. IV. cap. 9, § 3.

§ The original, which is from a fragment—ΥΠΝΟΣ—is as follows:—

> Εἶτ' εἰσὶν οἱ τέττιγες οὐκ εὐδαίμονες,
> ὧν ταῖς γυναιξὶν οὐδ' ὁτιοῦν φωνῆς ἔνι.

‖ "Mémoires pour servir à l'histoire des Insectes," Tome V., Pl. XVII. 1740.

mental point—was not sufficiently called to accessory parts. Carus inquired into the connection of the apparatus of song with that of respiration.* He shows that the interior of the abdomen forms a considerable air-chamber, and records the discovery of a pair of stigmata which enable that cavity to communicate with the exterior. Colonel Goureau, in an essay upon Stridulation,† only just touched upon the subject; but his memoir was completed in the same year by M. Solier.‡ Dugès § announced the existence of the tensor muscle of the drum, but M. Carlet—Professor in the Faculty of Sciences at Grenoble—the author of a very recent memoir ‖ to which we are indebted for the main facts embodied in this article, has searched for it in vain, and hopes to demonstrate conclusively that it has no existence. Doyère, in the Crochard edition of the "Règne Animal" of Cuvier, gives figures of the vocal apparatus; but they are incomplete, and the magnifying power is not sufficient to show the details.¶ Besides this, they only represent the exterior of the musical organ. M. Carlet has recently contributed two notes to the "Comptes Rendus," ** one upon the stigmata of the Cicada, the other upon a muscle of the musical apparatus, described under the name of *tensor of the folded membrane* ("membrane plissée"), which will be studied in detail further on.

As regards the question whether the sound produced by the Cicada can be properly termed its *voice* or not, Aristotle laid down the principle that those animals alone which respire can be said to have a voice; and as he believed that insects did not respire, they, according to him, only produce *sounds*.†† Réaumur states, on his side: "If we give the name of voice only to the kind of sound produced by air driven out of the lungs, and which, on its exit from the larynx, is modified by the glottis, insects have no voice. But if we believe it to be necessary to

* *Ueber die Stimmwerkzeuge der italiänischen Cicaden.* "Analekten zur Naturwissenschaft und Heilkunde," 1829.

† *Essai sur la Stridulation des Insectes.* "Annales de la Société Entomologique de France," Tome VI., 1837.

‡ *Observations sur quelques particularités de la Stridulation des Insectes, et en particulier sur le Chant de la Cigale.* Ibid.

§ "Traité de Physiologie comparée," Tome II. 1838.

‖ *Sur l'Appareil musical de la Cigale.* "Annales des Sciences Naturelles," 6ième série, Zoologie, Tome V.

¶ Insecta. Pl. xlv., figs. 2c′, 2f; figs. 4 and 5 of the plate, illustrating this article.

** *Sur l'Appareil musical de la Cigale.* "Comptes Rendus de l'Académie des Sciences," 1876.

†† "Φωνεῖ μὲν οὖν οὐδενὶ τῶν ἄλλων μορίων οὐδὲν πλὴν τῷ φάρυγγι· διὸ ὅσα μὴ ἔχει πνεύμονα, οὐδὲ φθέγγεται." "De Animalium Historia," Lib. IV., cap. 9, § 1.

give more extension to this term, if we agree that all the noises ('bruits'), that all the sounds ('sons'), by means of which animals induce those of their species to perform certain actions deserve the name of voice, then we shall find as regards voice among insects and the organs of that of the Cigale, that they will be well worthy of our admiration."

Dugès proposed the word "stridulation," which has since become classical, to designate the sound caused by the vibration of solid plates; but he reserved the name of "voice" for that produced in a larynx by means of expired air. But in these days it has been fully demonstrated that in the act of *phonation* it is the vocal chords which form the vibrating body, while the current of air is simply the motor element; the cavities of the pharynx and the thorax acting as a veritable sounding-box. All these elements, then, are to be found in the musical apparatus of the Cicada, the vibrating body being there represented by the "timbales," the motor agent by the muscles of the "timbales," and the sounding board by the cavities of the thorax and abdomen. In both cases, then, it is a vibrating membrane which produces the sound; the sole difference being in the fact that, on the one hand, this membrane is set in motion by a current of air, while, on the other, it is put in vibration by a motor muscle. From this it follows that there will be no incongruity in preserving the name *song* to indicate the vocal manifestations of the Cicada, although, scientifically speaking, the term *stridulation* would be preferable. In the neighbourhood of Grenoble the Cicadæ usually sing from the season of the flowering of the vine until the second week in August.* The *Cicada hæmatodes* is the first to appear, but does not sing much longer than the middle of July, when the *C. plebeia* begins to be heard, thus soon completely replacing the former. It is only during the day that the Cicada sings, and almost only during the sunshine —"sole sub ardente," as Virgil sang.† The large green grasshopper, which is often erroneously taken for the Cicada, on the contrary, makes itself heard during the night; and its *zic, zic,*

* The parallel of the forty-fifth degree of North latitude, on which the town of Grenoble lies, is a northern limit which the Cicadæ scarcely transgress in France. Nevertheless, they are to be heard a little, in all years, in the vineyards of Burgundy, and some specimens may even be taken in the neighbourhood of Fontainebleau. Pliny states that the voice of the Cicada is loudest at the solstices—'circa solstitium.'—Nat. Hist. Lib. XI. 107.

† "The cicada is supposed by some to pipe only during mid-day, but both in Central America and Brazil I found them loudest toward sunset, keeping up their shrill music until it is taken up by night-vocal crickets and locusts."—Belt, "The Naturalist in Nicaragua," p. 312. London. 1874.

zic quite differs from the stridulation of the Cicada, which can be represented sufficiently correctly thus:

*dzsss - - - - - - - - - sssst.**

When the Cicada sings in a state of freedom, it keeps rapidly moving its abdomen, depressing and raising it in turns, so as to approximate or separate the *opercula* ("volets"); of which organs more anon. During this period the wings are motionless and applied close to the body. But if the insect be in captivity, in a cage for example, the abdomen does not habitually show any movements during the song. Lastly, if one holds a Cicada between the fingers, it violently vibrates its wings and sets in motion all the free part of its body, uttering piercing cries which sensibly differ from its ordinary song; but soon the cries cease, and the wings droop immovable with fatigue.

Before proceeding to describe the special structure of the sound-producing organs of the Cicada, it may be as well first to state, for the information of readers who are not zoologists, that all members of the group *Insecta*, to which the Cicada belongs, have the body primarily divided into "head," "thorax," and "abdomen." These parts are further differentiated into rings, segments, or "somites," † of which the head usually has six, fused together, the thorax consisting of three, distinct and furnished with limbs, while the abdomen is made up of from seven to eleven, usually nine, "somites," all limbless in the adult insect.‡ In nearly all perfect insects each ring of the thorax carries on its under side two pairs of legs; and on the sides of the two hindermost rings (the "meso-" and "meta-thorax") two pairs of wings or their representative organs. Our attention, however, need only be specially directed to the last "somite" of the thorax and the first two of the abdomen in the Cicada. All descriptions hitherto given by authors of the musical organs of the Cicada are copied from Réaumur, and, inasmuch as they are incomplete and inexact, fail in clearness. The following description of them will be founded upon the record of the researches of M. Carlet, to which reference has been already made.

* "Added to these noises were the songs of strange cicadas, one large kind perched high on the trees around our little haven, setting up a most piercing chirp; it began with the usual harsh jarring tone of its tribe, but this gradually and rapidly became shriller until it ended in a long and loud note, resembling the steam-whistle of a locomotive engine."—Bates, "The Naturalist on the River Amazon," p. 230. 3rd edition. London. 1873.

† From the Greek word σῶμα, "a body."

‡ The sole exception is a beetle (*Spirachtha eurymedusa*), whose third, fourth, and fifth abdominal somites carry two-jointed limbs.—Vide Professor Macalister's "Introduction to Animal Morphology," . 386, Lond. 1876.

The Cicadæ, which are the subject of M. Carlet's memoir, were principally *Cicada plebeia* and *C. hæmatodes*, and were found in the environs of Grenoble. As many vivisections were made, his observations must be more searching than those of Réaumur, who only examined dry specimens or those preserved in alcohol. *C. orni* and *C. maculata* have also been dissected in the dry state. *C. plebeia* is, however, regarded by M. Carlet as the type of the genus and as the "classical Cigale."

For description, the body of the insect will be supposed to be placed vertically, the head being above and the belly directed forwards.

M. Carlet, for the sake of clearness, divides his description into an anatomical and a physiological section. Under the former category are comprised:—

1. The Framework ("charpente") of the Vocal Apparatus.
2. The Vibrating Membranes.
3. The Muscles in relation with the above.
4. The Sonorous Cavities.
5. The "Stigmata," or orifices of communication of these cavities with the exterior.

A. *The Framework of the Vocal Apparatus.*—This includes the last "somite" of the thorax (*metathorax*) and the five or six first segments of the abdomen.

1. The *Metathorax.*—On the lower border of this "somite," in front of and between the "peritrema" (a horny circle surrounding the opening of a stigma, *s*, figs. 1, 2, 3), may be seen a small chitinous * point, of which more anon, termed the apophysis of the folded membrane ("membrane plissée" *ap*, fig. 3.) The metathoracic segment is roofed in by a partition (*entothorax*) made up of two wing-like branches, having between them a mesial slit. The most salient part, however, of this somite is the organ called "volet" † by Réaumur, and otherwise known by the name of *operculum* ‡ (*v*, figs. 1 and 3). This is nothing more than a prolongation of the *epimeron*,§ and is not movable, as Réaumur believed. It is greatly developed in *C. plebeia*, and has the shape of a semicircular scale of which the rounded edge descends as far as the second ring of the abdomen. It is necessary to raise it on either side in order to bring the anterior part of the musical apparatus into view. In female Cicadæ these structures are rudimentary, and do not

* *Chitine* is a horny substance, insoluble in caustic potash, of which almost all the hard parts of insects consist.

† French, "a shutter." ‡ Latin, "a lid."

§ One of the twopaired lateral elements of the *pectus* or lower half of a thoracic "somite."

sensibly differ from the *epimera* of the other thoracic segments.

At the upper and internal angle of the epimeron of either side is to be seen the first joint (*coxa* "hanche," P. figs. 1, 2, 3,) of the leg of the third pair. It is accompanied by an appendage called "cheville" (*c*, figs. 1, 2), by Réaumur, which is none other than the *trochanter* of the thigh which has taken on a great development, and is received, in part, into a slight depression in the *operculum*. This arrangement led Réaumur to believe that the *trochanter* acted as a check to prevent the *operculum* from moving too much—an error, as the latter is quite immovable.

2. The first abdominal segment. This may be conveniently divided into a peripheral, and a central part.

a. The peripheral part. This "somite" is narrow behind, and forms on its sides the upper border of the frame of the drum ("cadre de la timbale"). This border divides in front into two branches, which eventually form two ridges ("arêtes") of a triangular pyramid, termed by M. Carlet the "tetrahedron," which has its apex at their point of divergence. There are, moreover, four sides, or faces, of which one forms the base of the tetrahedron, while that which is bounded by the anterior and posterior ridges is pierced for the first stigmatic orifice (*s*, fig. 1) of the abdomen. There are two symmetrical tetrahedra.

b. The central part, which comprises the *entogastrium* (Audouin, *op. cit.* p. 125), or "triangle écailleux" of Réaumur. M. Carlet proposes to retain the first term, as a reminder that the part is homologous with the entothorax. The entogastrium somewhat resembles a bird with a forked tail and wings spread out. A median crest is developed upon the hinder part of its body, affording insertion for the motor muscles of the "timbales" (fig. 1).

The second segment of the abdomen is very broad behind and on the sides (2*a*, fig. 2), but becomes much narrower in front (2*a*, fig. 3), clasping by its concavity the preceding somite, with which it becomes completely fused in the middle line. This arrangement is exactly the reverse of that of the first segment, but is to be found only in the male insect. Laterally there will be found in the second segment a kind of inclined plane, resting upon its upper margin, which M. Carlet terms the floor of the cavern ("plancher de la caverne"), as it forms the lower surface of this cavity (C, figs. 2, 3). A large chitinous scale ("apophysis of the cavern," *ap*, figs. 1, 3), is to be seen at the junction of the part just described with the second abdominal ring, which forms the outer wall of the cavern. It is triangular, completely masking the drum, to see which it must be lifted, and is itself in turn covered by the lower (or hinder) wing, when this is at

rest. The other abdominal segments, which help to make up the lower part of the framework of the musical organ, present nothing worthy of note, except that each has a stigma on the ventral surface.

B. *Vibrating Membranes.*—The principal are the three following: the *drum* ("timbale,") the *mirror* ("miroir,") and the *folded membrane* ("membrane plissée,"), and are all situated in pairs on either side of the median plane.

1. The *drum* ("timbale" of Réaumur) (*t*, figs. 1, 2, 3), sometimes also termed "tympan," is translucid, and is imbedded in a rim ("cadre,") from which it projects into a hollow called the *cavern.* In coincidence with its rim the circumference is elliptical. Of its surfaces the outer one is convex (*t*, fig. 2), and is furnished with five or six chitinous arches, while the inner surface is concave. At the hinder point of junction of the arches is a thickened spot where the tendon of the motor muscles of the drum is inserted (fig. 1). The membrane itself is composed of an epidermic tissue made up of lozenge-shaped cells. In females the drum is represented by a chitinous scale imbedded in a rudimentary tympanic rim.

2. The *mirror.*—The membrane so named by Réaumur is stretched between the lower borders of the wing of the *entogastrium*, the base of the internal surface of the *tetrahedron* and the ventral part of the first abdominal somite (*mi*, figs. 1, 2, 3). It is in the form of a semicircle, of which the diameter is the internal edge of the *wing* of the *entogastrium*, (vide fig. 1). It is a flat and diaphanous plate of extreme thinness, having in its middle iridescent rings. Microscopically it is made up of a layer of lozenge-shaped cells, like those of the drum, but much more delicate. The two mirrors are separated in the middle line by the *body* of the *entogastrium* (vide fig. 2). They are, lastly, rudimentary in the female insect.

3. The *folded membrane* ("membrane plissée," *m p*, figs. 1, 2, 3).—This organ is soft in the fresh state, and transversely folded in repose, whence the name given to it by Réaumur. By its laxity it differs from the drum and the mirror, which are always dry, *ergo*, more or less tense, membranes. It is, moreover, opaque, while the first named is translucid and the latter diaphanous. It has the form of a rectangle, of which the two surfaces are directed anteriorly and posteriorly. The membrane itself is composed of two layers, one superficial, of elastic fibres, the other deep, of the nature of a lining membrane. The elastic fibres lie parallel and are folded zigzag-wise. It is, like the preceding organs, rudimentary in the female Cicada.

C. *The Muscles.*—There are three pairs, of which only one has been previously described by naturalists. They are symmetrical, two and two, and are absent in the female.

1. *The motor muscle of the drum* (*m m*, fig. 1).—This is the most important. Réaumur, who discovered it, gave it no particular name, but M. Solier termed it "the musical muscle." This name should be abandoned, as it shares the music-producing function with two other sets of muscles. According to Dugès (*op. cit.* Tom. ii. p. 228), another muscle of the drum—"très-petit, caché sous le bord inférieur du cadre de la timbale qui l'a dérobé aux anatomistes, a pour usage peut-être d'augmenter la tension de la timbale." M. Carlet, however, does not believe in its existence, and promises to demonstrate that, even were it present, it would completely spoil the action of the musical apparatus. The tensor of the drum is the most bulky muscle in the Cicada's body. It takes its *fixed* origin from the whole extent of the entogastric crest; whence its fibres pass outwards and backwards to abut upon a disk, from which there proceeds a short tendon to a *movable* point of insertion upon the drum. At the junction of the two trunks of this muscular cone is to be seen a membrane which assumes the form of a half-ring (*x*, fig. 1). This goes horizontally to be inserted upon the *tergum** at the junction of the first two abdominal somites, only leaving between itself and this part just space enough for the passage of the dorsal vessel. In conjunction with its fellow this membrane forms an oval ring, allowing of communication between the cavities of the thorax and abdomen. The fibres of the tensor of the drum are of the *striped* kind, and are inserted into an elliptical disk ("plaque cartilagineuse" of Réaumur), from which the triangular tendon arises, to be attached by a membranous tongue to the postero-inferior part of the rim of the drum.

2. *Tensor of the folded membrane.*—This muscle, which M. Carlet believes that he was the first to describe, is cylindrical in form (*m t*, fig. 1), and has its *fixed* origin from the upper border of the frame of the drum, while its insertion (*movable*) is at the posterior part of the apophysis of the folded membrane. It, too, belongs to the *striped* variety; and, as in the preceding muscle, between its fibres and the point of insertion there intervenes a conical disk carrying a very short tendon.

3. *The sterno-entogastric muscle* (*m s*, fig. 1).—This name is derived from the two points of origin and insertion. The muscle passes longitudinally from the apex of the entogastrium to a triangular projection springing from behind the upper point of the *sternum* of the metathorax. The fellow muscles lie very close to one another on the middle line, and communicate with the deep surface of the folded membrane.

D. *Sonorous Cavities.*—Under this general term are comprised

* The *tergum* is the upper or dorsal element, or factor, of a thoracic segment, the insect being placed upon its legs.

those cavities in the body of the Cicada which are filled with air, and where this ethereal fluid is thrown into waves by the vibrations of the drum. They are five in number—one median and four lateral.

1. The *thoraco-abdominal cavity*—the "grande cavité" of Réaumur, is formed by the junction of two (thoracic and abdominal) cavities. It comprises the internal cavity of the metathorax and the five or six first abdominal somites, and is roofed in by the entothoracic partition, which gives attachment to the muscles of the legs and wings of the metathorax, while below it terminates in a vast *cul-de-sac*, at the bottom of which the abdominal viscera are packed.

It is constricted at its middle by the "oval ring," mentioned above, which is stretched between the muscles of the drum (*x*, fig. 1); and reminds one of an hour-glass, of which the upper bulb would be the thoracic cavity, and the lower that of the abdomen.

2. The "*second cavern*" (Dugès), termed by Réaumur the "cellule" (C, figs. 1, 2, 3). Its entrance is concealed by the *operculum*, which must be lifted in order that it may be seen. The cavity itself is a *cul-de-sac*, of which the external wall is concave, and shows an opening in the shape of a narrow slit, which is covered by the *scutellum* * of the metathorax.

3. The *sub-opercular cavity* is a vast chamber covered by the *operculum*, bounded above and below by the folded membrane and the mirror respectively (fig. 3). It is completely closed in *C. plebeia* when the abdomen is lowered, but when this part of the body is raised it is open below and on the two sides. The two cavities are separated one from the other in the middle line by the body of the *entogastrium*.

E. *The Stigmata.*†—Their action, though but little studied as yet, is of the greatest importance. Léon Dufour ‡ states that the Hemiptera — to which order the Cicada belongs — have generally but one pair of thoracic stigmata, and that those of the abdomen of the Cicada are six pairs in number; but M. Carlet has found that there are three pairs of thoracic stigmata (in both sexes) and seven pairs in the abdomen. The third and lowest pair in the thorax are to be found beneath the *operculum*, or *epimeron* of the metathorax (*s*, figs. 1, 2, 3). The first abdominal stigma (*s'*, fig. 3) will be seen on the internal

* In English, "little shield." It is one of the four elements of the *tergum*, or upper section, of a thoracic "somite."

† The air-holes which communicate with the *tracheæ*, or air-tubes, in Insects. The word is the plural of the Greek στίγμα, "a spot."

‡ Recherches anatomiques et physiologiques sur les Hemiptères." p. 257.

surface of the "tetrahedron," while the stigmata of the second pair (s'', fig. 3) are sometimes obliterated, and consequently less easily seen than the others.

The stigmata of the thorax differ from those of the abdomen not only by their position, but also by their shape and structure; the former being well developed, furnished with a horny rim (*peritrema* *), edged with hairs, and with a movable valve which opens and shuts like an eyelid, while the latter are mere punctures, devoid of the above accessories. The stigmata in connection with the sonorous cavities, to wit, those of the metathorax and the first of the abdominal pairs, claim special attention. The first named has a chitinous *peritrema*, and two eyelid-like valves, furnished with lashes, of which the lower alone is movable. In *C. plebeia* it debouches directly into the metathoracic cavity, but in *C. hœmatodes* communicates with a large air-vessel, which ramifies over the upper surface of the muscles of the drum.

The first stigma of the abdomen (s', fig. 3), is situated in the internal surface of the "tetrahedron," a little above the mirror, and consists of a little round orifice, debouching into a tracheal trunk, which eventually breaks up into numerous branches.

The Mechanism of Stridulation.—In order rightly to understand its functions, it will be best to study separately the *rôle* of each of the factors of which it is made up.

It is a mistake to suppose that the framework of the vocal organ acts merely as a support and a guard for the vibrating elements. On the contrary, it is in itself an admirably arranged organ of vibration; it can, in fact, be said that the whole body of the Cicada vibrates when it is in song. For the *tergum* of the prothorax may be seen to tremble during the chant, and if the vibrations of other parts of the body are less obvious, they can at any rate be rendered apparent by putting them to the proof of touch. As regards the *rôle* of the membranes and their muscles, a distinction must be made between those which vibrate *directly*, and those which do so secondarily *by influence*. The former, or the drums, are put in motion by special muscles, while the latter—the mirrors and folded membrane, are excited by the vibrations of the drums. With regard to the drums—if these be removed while the insect is singing, the sound will immediately cease; but if they be left intact, while the others are removed, the song, though weakened, will continue to be heard. The drum is therefore the sound-producing organ, the vibrating body, which, throwing the air into waves, acts upon the neighbouring membrane. Réaumur discovered this fact by pulling the muscle of the drum in a dried specimen of the

* From the Greek περὶ, "around," and τρῆμα, "a hole."

Cicada. After having been excited by its motor muscle, the drum returns to its state of rest by virtue of its elasticity,* an effect aided by the chitinous bands. Some authors have stated that the drum becomes concave at the moment of the contraction of the motor muscle, but the real fact is that, with the exception of a very slight depression at the point of attachment of the tendon, the membrane constantly retains its convexity, and never yields, at all events, in adult insects. In young specimens, however, the drum, having less power of resistance, is rendered somewhat concave by the action of the muscle, and this peculiarity was utilized by M. Carlet to demonstrate the synchronism in the vibration of the drums. For if these be exposed, by cutting the wings of a young specimen of *C. hœmatodes*, they will be seen, during the song, to be at one and the same time both concave or both convex.

M. Solier, after carefully examining the muscle of the drum during song, was not, even by the aid of a lens, able to distinguish the slightest movement; but M. Carlet, on repeating the experiments, plainly observed a to-and-fro motion of the muscle, and concludes that M. Solier must have experimented on a Cicada already tired out. M. Carlet has further attempted to register the vibrations of the drum, and by the following method. A long needle of glass, drawn out to a thread in the flame of a spirit-lamp, was fixed at a tangent by means of a little wax to the exposed drum-membrane, and the insect, held by the end of its body, while in song, was made to trace the vibrations on smoked paper rolled round a cylinder rotating by clockwork,† simultaneously with tracings of a standard tuning-fork. By comparing the two sets of tracings thus obtained, the number of vibrations made in one second by the drum could be calculated. The numbers cannot be given by M. Carlet, because they are not constant. The captive Cicada, however, cries rather than sings, the musical sound being probably modified by the mutilation to which the insect is subjected, as well as the embarrassment caused by the wax on the drum and the friction of the glass index against the smoked paper. It has been stated some pages further back that there is no tensor muscle of the drum, and that if there were one, it would be a hindrance rather than a help. The reason is this—that the membrane,

* This is a good example of physiological economy. Similar instances may be found in the passive action of the costal cartilages in antagonism to the active contraction of the muscles which expand the chest in respiration, and in the elasticity of the hinge in passive opposition to the *adductor* muscle which closes the two valves of the shell in the oyster.

† An apparatus probably resembling the well-known arrangement of Professor Marey.

dry and parchment-like naturally, has no need of being put in tension. More than this, it is convex, and a tensor muscle would but hinder it from returning to its natural convexity; in other words, would act in opposition to its vibrations.

Membranes vibrating secondarily by influence. The mirror and the folded membrane. — Réaumur was aware that the mirrors served to reinforce the sound produced by the vibrations of the drums. Without doubt, too, they are useful in preventing the entrance of foreign bodies into the abdominal cavity, which would interfere with its power of resonance. The vibrations of the mirrors may be demonstrated by sprinkling fine dust over their surface, which will dance as soon as the song begins.

The folded membrane would seem, at first sight, to be but ill adapted for the reinforcement of sound, as it is lax and soft in the fresh state. Sufficient tension, however, is brought about by its special tensor muscle, which is, in turn, antagonized by the sterno-entogastric muscle. The former acts by drawing the apophysis, at the point where it has its *movable* insertion, outwards and backwards. The absence, moreover, of this muscle in the female insect is an indirect proof of its action, which can be distinctly shown by dividing it with a fine pair of scissors, when a diminution in the intensity of the sound will be perceived. As regards the sterno-entogastric muscle, its *rôle* is somewhat complex; but M. Carlet concludes, after elaborate experiments, that in its active condition, or that of contraction, it approximates the thorax to the abdomen, at the same time puckering the folded membrane; while in its passive state, or that of relaxation, it draws this membrane closer and renders it plane throughout its whole area, thus coming to the aid of the tensor muscle in facilitating its vibrations.

The Functions of the Sonorous Cavities and the Stigmata. —The thoraco-abdominal cavity differs from the others in that it alone is brought into communication with the outside by stigmata, while the other cavities communicate freely and directly with the exterior. The first-named cavity represents a drum with two membranes, of which the case is chitino-membranous, the function of the two skins being fulfilled by the "timbales." As for the *rôle* of the stigmata, it can be fairly likened to that of the opening of the Eustachian tube in the tympanic cavity of the organ of hearing, their office being to bring about equilibrium in tension between the external air and that confined in the cavity into which they lead. The difference in tension between the imprisoned air and that outside must certainly be at its maximum during the contractions of the motor muscles of the drum, because of the heat set free by their molecular action; and the eyelid-like stigmata are accordingly to be seen

opening and shutting by turns during the song of the Cicada. With regard to the caverns and the subopercular cavities—the former perform, in relation to the "timbales," the same *rôle* as do the subopercular cavities in relation to the mirrors and folded membranes. If the abdomen in a living Cicada be raised in such wise as to open the above cavities, the sound immediately increases in intensity, just as when the windows are opened in a room in which a musician plays, those outside can hear better. If, on the contrary, the abdomen of the same insect be depressed, so as to cause it to rest against the *opercula*, the sound becomes muffled; and the same effect is produced by the Cicada when free, by suddenly depressing its abdomen after it has been raised, and it is to such oscillations of the abdomen that the *accentuated* song of *C. plebeia* must be attributed.

About ten years ago, M. Landois, in a most valuable paper on the vocal organs of insects,* demonstrated that the "timbale" of Réaumur cannot act in the manner described above, since, instead of being movable by muscular action, it is firmly attached to the wall of the metathorax. "The song of the Cicada," he concludes, "is its voice. This is produced by the air from the trachea setting the vocal chords of the metathoracic stigma ('Schrillstigma') into vibration. The shell-like membrane in the chitine ring ['timbale'] and the delicate membranes at the bottom of the cavities ['folded membrane'] are merely an apparatus of resonance." Dr. Paul Mayer, as the result of some recent experiments made upon *Cicada orni*, in the Zoological Station at Naples, arrives at almost the same conclusions as M. Carlet." †

Touching a "schema" of the musical apparatus of the Cicada. After studying the mechanism of a *physiological* apparatus, we ought always, thinks M. Carlet, to have in our mind's eye the construction of a *physical* apparatus which, while reducing the first to its simplest expression, nevertheless reproduces the principal peculiarities of its action. A schema of the vocal organ of the Cicada is easily constructed. A little slip of metal is taken, having a groove on its inside edge, and bent in the form of the letter U. Into each groove a thin plate of steel is next fitted in such wise as to obtain two parallel springs, free for half of their length. Before introducing the two plates, there should be made in the centre of the outer surface of each a slight but permanent depression; and an instrument is finally obtained somewhat analogous to the ubiquitous toy recently

* *Die Ton-und Stimmapparate der Insecten in anatomisch-physiologischer und akustischer Beziehung.*—"Zeitschr fur wissensch. Zoologie," bd. xvii. s. 105; and Taf. xi. figs. 17, 18. 1867.

† *Der Tonapparat der Cicaden.*—*Ibid.* bd. xxviii. s. 79. 1877.

brought out under the name of "Cri-cri." In order to make the model act, all that is necessary is to hold the frame of the instrument in the left hand, while with the thumb and forefinger of the right the free portion of the two steel springs is alternately and rapidly brought together and again let go; and, as the depression in the two plates thus becomes by turns convex and concave, a stridulation is produced which is a fair imitation of the sound of the Cicada. The drums are imitated by the depression in the steel springs, while the motor muscles of the former are represented by those of the left hand.

The musical apparatus of the male Cicada is classed by Mr. Darwin ("Descent of Man," vol. i., p. 350) as one of the "secondary sexual characters" among insects. *Apropos* of this he quotes (*op. cit. p.* 351) from a journal of Dr. Hartman, the following about *C. septemdecim* in the United States:—"The drums are now heard in all directions. This I believe to be the marital summons from the males. Standing in thick chestnut sprouts about as high as my head, where hundreds were around me, I observed the females coming around the drumming males." Fritz Muller, moreover, wrote to Mr. Darwin from S. Brazil that he has often listened to a musical contest between two or three males, who had a particularly loud voice, and were perched at a considerable distance from each other. "As soon as the first had finished his song, a second immediately began; and after he had concluded, another began, and so on." If there is so much rivalry between the males, it is probable that the females not only discover them by the sounds emitted, but that, like female birds, they are excited or allured by the male with the most attractive voice.

EXPLANATION OF PLATE X.

In all the Figures the corresponding parts are indicated by the same letters. The body of the Cicada is supposed to be placed vertically, the head being above. The three first figures are taken from the plate (Pl. XI.) illustrating M. Carlet's article in the *Annales des Sciences Naturelles.*

FIG. 1. The interior of the musical apparatus, seen from above; a vertical transverse section having been made across the body of the insect. The muscle of the drum, the folded membrane, and the *operculum,* have been removed on the left side. On the right is seen the muscle of the drum, its small triangular tendon, and its semi-annular membrane, also the tensor muscle of the folded membrane, and the lower part of the sterno-entogastric muscle in section. The deep aspect of the drum,

of the folded membrane, and of the *entogastrium*, as well as the internal opening of the metathoracic stigma, are likewise to be seen in this figure.

FIG. 2. The same apparatus seen from the side (left). The whole of the *apophysis* of the "cavern" has been removed in order to show the drum. A partial section has also been made of the *operculum* in order to show *en profile* the greater part of the details of the following figure.

„ 3. The anterior part of the musical apparatus. A section of the *operculum* on its left side has been made to show the contained organs. In order that the drum may be better seen, the bottom of the "cavern" has been raised, its entrance remaining intact.

„ 4. The lower part of the thorax and abdomen of the male of *Cicada plebeia*, seen from beneath. After fig. 2 *c′*, Planche XLV. of Cuvier's "Règne Animal: Insecta."

a. *Epimeron* of mesothorax.
β. *Epimeron* of metathorax.
γ. First abdominal "somite."

„ 5. The musical organ of the same insect laid open and seen on its ventral aspect. *Ibid.* Fig. 2, *f*.

A. Orifice of insertion of the hinder wing.
1*a*. First abdominal segment.
2*a*. Second „ „
3*a*. Third „ „
a p, Apophysis of the folded membrane.
C, "Cavern."
c, "Cheville" of Réaumur, or *trochanter* of leg of the third pair.
e, The "wing" of the *entogastrium* in fig. 1, its "body" in fig. 2. *m i*, "Mirror."
m m, Motor muscle of drum.
m p, Folded membrane.
m s, Sterno-entogastric muscle.
m t, Tensor of the folded membrane.
P, Leg of the third pair.
s, Stigma of metathorax.
s′, First abdominal stigma.
s″, Second „ „
t, Drum ("timbale").
v, *Operculum* ("volet").
x, Semi-annular membrane of the muscle of the drum.

CAVES AND THEIR OCCUPANTS.

ILLUSTRATED BY THE BONE CAVES OF CRESWELL CRAGS.

BY THE REV. J. MAGENS MELLO, M.A., F.G.S., ETC.

CAVES and their exploration have for a considerable number of years past excited a great amount of interest in the scientific world. The Physicist, the Archæologist, and the Geologist have each in their turn found in them much to occupy their attention. Physical Geology has gained from cavern researches an insight into some of those vast operations of Nature, which, carried on quietly and persistently during an incalculable number of years, have done so much in many parts of the earth, in its secret recesses, to fashion and sculpture its rocky crust. We have been taught how in numerous instances the extensive and deep valleys of our limestone districts have been actually formed by the dissolution of the solid rock, through the agency of water charged with carbonic acid gas; whilst the same rock, redeposited in an altered form, has built up those thick beds of calc-tuff so common in the same localities. The study of cavern-structure has also led to our understanding much as to the formation of mineral veins, and has brought to light many strange facts as to the circulation of subterranean water. But to many the chief interest of caverns consists in the contents so often buried in their floors, in the remains of the ancient tenants—wild beasts and men—by whom they have been alternately occupied.

Caves are common to all parts of the world, and may be met with in rocks of very varied age; not alone in the Carboniferous or Mountain Limestone, in which they are so very frequent, but also in the older limestones of Silurian age, and in those of the younger Permian and Jurassic rocks. Even sandstone rocks are in many instances, especially where exposed to marine denudation, found to be excavated into caverns of greater or less extent.

Every country has its caves. All have heard of the gigantic Mammoth Caves of Kentucky, in America, the ramifications of

which extend for miles, and in which, quite recently, most interesting relics of their early Indian inhabitants have been discovered. The famous water-caves of Styria, with their underground rivers and their magnificent stalactites, are well known to travellers; and in Sicily, Italy, Spain, France, Belgium, and England, as well as in distant Australia and New Zealand, caves of varying extent are numerous. In many of these recent explorations have discovered relics of early occupation that have proved of the utmost value to science.

A great number of caves have been found to contain so many remains of their former occupants, as to enable us to trace the history of their habitation during a long succession of ages, extending from the remote past of geological time to periods which are linked by history to the present.

Although there are some few caverns which yet contain traces of their having existed and been occupied in the Mesozoic epoch, yet in almost every case the records of cave occupation may be said to begin with that latest period of the geologist known as the Pleistocene; and we find that then, as now, the caves and dens of the earth were a refuge and hiding-place to the wild beasts. Here some of them lived and died, and here they dragged their prey, either overcome in the chase, or torn to pieces when feeble and dying. In those remote times the hyænas and the bears, the lions and the lynxes, and other carnivora, found their home in caves, just as these animals do at the present day, in the countries they now inhabit.

It is in caves that we meet with the first undoubted traces of man's existence on the earth. During some of the earliest stages of his history he appears to have used caves for the burial of his dead, and also as his habitation, often fixing upon those on the sunny side of a valley, and making them his home and his treasure-house. In the extreme north of the Asiatic continent it has been shown that a cave-dwelling people existed anterior to the Samoyedes. We read in Homer of cave-dwellers upon the shores of the Black Sea. Cave-tombs have been found in Australia, in the neighbourhood of the Gulf of Carpenteria; and we learn from the Pentateuch that the early inhabitants of Palestine buried their dead in caves; whilst recent African explorers have told us of a whole tribe of Troglodytes in the interior of that continent. Some writers have supposed that architecture itself may have had its origin in these primitive homes. From the remains of man—his weapons and his tools, his utensils and his ornaments—we may form a tolerably accurate idea of the habits and the amount of civilization, and of some of the conditions of life, of the early inhabitants of our own and of other countries. Speaking of some of the cave-dwellers in Western Europe, Sir John Lubbock writes: "Their

habits have been elucidated in the descriptions of their weapons and other implements, adapted for shooting or darting, stabbing, clubbing, cutting, chopping, scraping, boring, drilling, and other work wanted in either peace or war; in hunting or fishing, in domestic operations, and in designing the works of art which so markedly characterized this peculiar people. Their cooking stoves, hearths, and mortars; their bodkins and sewing needles; their personal ornaments, and amulets perforated for stringing; their whistling instruments, and their 'bâtons,' possibly distinctive of rank and dignity. Even their owner marks, tally scores, and probable gambling tools have been recognized and described, as well as how they made their many implements of flint."

Whilst there are some cave-remains which take us into so remote a past that we dare not assign any date to their first introduction, there are others which help to throw light upon some of the obscurer pages of history. Thus the celebrated Victoria Cave at Settle, in Yorkshire, not only carries us back to a period when the Craven savage passed through all the vicissitudes of a climate at one time mild enough for the hippopotamus to be an occupant of the Yorkshire rivers, and at another so severe in character that man may have struggled for a mere existence with the grizzly bear and the reindeer; but it also tells us how, in post-Roman times, the Brit-Welsh inhabitants of these islands were driven by the ever-advancing waves of Teuton invasion, to fly to the caves as their securest shelter and hiding-place. Here they dwelt for awhile, and by coins and various ornaments of considerable beauty and finish which they have left behind them, we are enabled, as it were, to decipher some few words in an almost illegible page of history.

Professor W. Boyd Dawkins, in his admirable work on "Cave Hunting," divides caves, according to the ages of their contents, into three classes—Historic, Prehistoric, and Pleistocene; the first being those in which remains of man or of his works have been found which can be assigned to some known historical period. In this country the occupation of Britain by the Romans is the extreme limit of age which can be admitted for historic caves, as previous to that event we have but the very dimmest tradition to guide us. Besides the human remains, those of certain animals, the approximate date of whose introduction into these islands is known, as well as the absence of others, will help us to determine the historic age of the bed in which they may be found.

The second class of caves, those called Prehistoric, are intermediate between the Historic and the Pleistocene: whilst remains of animals of late introduction are invariably absent

from them, those which specially characterize the still earlier Pleistocene deposits are equally absent; Man also, during the Prehistoric period, seems to have had much to do with the introduction of many of the domestic animals of Europe. "The dog, the domestic hog, the horned sheep, the goat, the Celtic short-horn, and the larger ox descended from the great Pleistocene Urus, make their appearance together with Neolithic man" (see "Cave-Hunting"); and "the wild fauna of Europe, as we have it now, dates from the beginning of the Prehistoric age, and consists merely of such animals as were able to survive the changes by which their Pleistocene congeners were banished or destroyed" (*ibid*). When we turn to the earliest class of caves, the Pleistocene, we at once recognize an enormous difference in the nature of their contents, when compared with those of the succeeding classes. First of all we are struck with the entire absence of any trace of the domestic animals in the Pleistocene deposits, whilst at the same time we encounter a large number of species, which either became extinct or else migrated to other climes before the commencement of the Prehistoric epoch, as for instance, the Cave Lion, *Elephas antiquus*, Glutton, Woolly Rhinoceros, Spotted Hyæna, *Rhinoceros hemitœchus*; Cave Bear, Bison, Mammoth, Hippopotamus, &c.

We still find the lion, the hyæna, and the hippopotamus in Africa, and the bison in Central Europe. It would appear from this migration and extinction of species that very considerable changes, both of climate and of physical geography, must have taken place between the Pleistocene and the succeeding period, involving an expenditure of time the length of which we have no certain means of estimating. The numerous researches which have been lately carried on into the contents of British caves show us that we have in this country a large number of caves representing more than one of the periods referred to; and that whilst some of the caves belong to the latest periods only, those which contain relics of the earliest period will contain also in their upper beds remains belonging to one or both of the later ones. Thus the Victoria Cave, which is in its deeper deposits of Pleistocene age, is linked to historical times by the presence of debased coins of some of the Roman Emperors, and also contains relics of Neolithic occupation. The Brit-Welsh, who were forced to seek shelter in caves from their powerful invaders, have left traces of their presence, not only in various caves in Yorkshire, but also in Staffordshire and Derbyshire, as well as in Lancashire, and as far south as Devonshire.

We must not confound the bronze ornaments found in these caves with the bronze implements, &c., which are sometimes found both in caves and tumuli of a very different date, and

which belong to Prehistoric times. The style of art displayed in these latter is of a very distinct type, which in its ruder forms of weapons shades off, as it were, into the still earlier Neolithic period.

But few remains of the Bronze age have been met with in British caves. The Neolithic period is more fully represented both here and abroad. The occupation of caves by the Neolithic men was general throughout Europe. Almost everywhere traces of these people have been met with who used the caves both as dwellings and as tombs. Not only are these men distinguished from the races which succeeded them by their physical conformation, but also by the character of their implements. These were made either of stone or bone; their stone implements being characterized by an amount of finish which is never found in those of the yet earlier men of the Pleistocene period. Their spear- and arrow-heads are elaborately constructed, and a large number of their tools and weapons are polished, so that the age in which they lived is sometimes called on this account the "polished stone age." Magnificent specimens of their implements have been found in Denmark, which for perfection of form and careful finish are unrivalled. Traces of Neolithic man have been found in the Victoria Cave and in caves in Wales; also in the celebrated cavern called Kent's Hole, in Devonshire, and in caves in Belgium, France, and elsewhere; besides others met with in lake-dwellings in Switzerland and in Ireland. Professor Dawkins has pointed out that these "Prehistoric peoples lived under physical conditions very different from those of Central and Western Europe at the present time, the surface of the country being covered with rock, forests, and morass, which afforded shelter to the elk, bison, urus, stag, *megaceros*, and wild boar, as well as to innumerable wolves. They arrived from the east with cereals and domestic animals, some of which, as the '*Bos longifrons*,' and '*Sus palustris*,' reverted to their original wild state. From the very exigencies of their position they lived partly by hunting, and they gradually pushed their way westward, carrying with them the rudiments of that civilization which we ourselves possess," and "the climate which they enjoyed was sufficiently severe to allow the reindeer to inhabit the district on which now stands the city of London. . . . The area of Great Britain was greater than now, since a plain extended seawards from the coastline nearly everywhere, supporting a dense forest of Scotch fir, oak, beech, and alder, the relics of which are to be seen in the beds of peat and the stumps of the trees near low-water mark on most of our shores."—("Cave Hunting.")

A period of unknown length, but which must have been very

great, separated the age of Neolithic man from his predecessor in the Pleistocene age,—a period in which vast changes, both of climate and physical geography, can be shown to have taken place; during this vast interval the separation of Great Britain from the continent of Europe took place, and an enormous amount of denudation, resulting in the excavation of extensive valleys, and the alteration of river-courses, made the England of to-day a very different country from what it was when the Palæolithic hunter and the Pleistocene mammalia were reckoned amongst its inhabitants.

During the Pleistocene, as during the later ages, men and wild beasts found their homes in the caves of the earth, and it is from caves that we have obtained the greatest amount of information relating to this most interesting period of the world's history.

As long ago as the beginning of the present century evidence began to be collected which tended to show that man was living in Europe in company with numerous wild animals, now either totally extinct or only found in far distant regions, such as the mammoth, the woolly rhinoceros, the hyæna, and the lion. The first evidence of this sort was obtained in Kent's Hole, in which flint implements were found in intimate association with the bones of these and other animals. The exploration of this cavern has been energetically pursued during a long series of years with most valuable results. In the same part of England similar evidence was obtained from some caves at Brixham; and later on numerous caves in this country, notably Wokey Hole in the Mendip Hills, and an extensive series of caves in Belgium and in France, have yielded to careful research such an amount of evidence, that the fact is now firmly established that man was a contemporary with a wild fauna now partially extinct, which existed in these countries under climatal conditions very different from those now prevailing.

It is somewhat startling at first, when we come to realize that in this country, now so free from wild animals, there was a time, and that time the human period, when a most formidable array of the larger carnivora roamed at will through vast forests which then spread over a great part of these isles, and yet no fact rests upon more certain evidence: from the floors of numerous caverns large quantities of the bones and teeth of these animals, representing individuals of all ages, have been extracted, many of them in the most perfect state of preservation.

Some of the latest and not least important additions to our knowledge of the Pleistocene age, and of man's coexistence with its wild fauna in England, have been made by the recent discoveries in the Creswell caves in north-east Derbyshire; and a short account of their exploration, and of the results obtained,

will show something of the nature of cave researches, and will at the same time also assist us in picturing to ourselves some of the conditions of life during what we may look upon as the dawn of the human period in Great Britain.*

The caves of Creswell are beautifully situated in a small craggy ravine in the Magnesian Limestone on the border of the counties of Derby and Nottingham (fig. 1.). They are of no great size, being little more than enlarged fissures. Three of these have been carefully examined since their discovery as bone caves by

FIG 1



VIEW OF CRESWELL CRAG, LOOKING EAST †

the writer in 1875, and they are known as the Pin Hole, the Robin Hood Cave, and the Church Hole. The last two are the largest and also the most important, especially on account of the abundant traces of man's handiwork in conjunction with very numerous bones of the extinct mammalia, which are distributed throughout the soil forming their floors.

The Pin Hole cave is a long and narrow fissure, containing under a thin crust of recent surface soil a bed of red sand about three feet thick. This was found to be full of bones, many of them broken and gnawed, belonging to about eleven genera of mammals of the Pleistocene period, but without any distinct traces of man's presence, although there are, as we shall see, so

* See Papers by Professors Busk, W. Boyd Dawkins, and the writer, in the "Quart. Journ. Geol. Soc." for November 1875, August 1876, and August 1877.

† This and the other figures illustrating this paper, have been kindly lent to us by the President and Council of the Geological Society.

many in the adjoining caves. This, however, is what might be expected; the larger and more commodious caves would certainly have been preferred to the narrow fissure, by the early inhabitants, for a house or sheltering-place. When we come to notice the animal remains we shall find but little difference in the contents of these caves, the presence or absence of some species in one or other of them being evidently accidental. The two larger caves, the Robin Hood and the Church Hole, were found to contain a considerable thickness of deposited material; and a reference to the sections (figs. 2, 3) will serve to show how the floors of bone caves are built up. Sealed up under a crust of stalagmite and breccia a series of well-marked beds were found. This stalagmitic breccia consisted of masses of limestone fallen from the roof, and cemented together during the lapse of an indefinite period of time by the constant dripping of water charged with carbonate of lime. Below the breccia was a deposit of sandy earth, commonly known as cave earth, of variable thickness, and passing at its base into a curiously mottled bed of reddish earth, filled with light-coloured fragments of friable limestone; this in its turn rested on red sand, similar to that mentioned as occurring in the Pin Hole, and under this was the decomposed floor of the cavern, the whole amount of deposited materials being about eight or nine feet thick. It may be observed that the contents of the Robin Hood and Church Hole caves were very similar to each other, and were probably brought in at the same period under identical conditions.

It is in these various beds, forming the floors of the caves, that the bones and implements have been obtained which enable us to reconstruct the life-history of the past.

Commencing our researches in the surface-deposits in the Church Hole and the Robin Hood caves, we are at once carried back into that unsettled period of British history when the Roman legions were withdrawn, and the comparatively civilized British population had to resist as best they might the hordes of Teuton invaders, for in the surface soil of these caves a few traces of Romano-British art have been met with: these consisted of two or three harp-shaped and circular brooches, one of the former being enamelled with blue. In conjunction with these, numerous fragments of pottery, one or two being of the well-known red Samian ware, were found; and the surface-soil also contained a large number of bones of animals common at that time, such as the sheep, goat, Celtic shorthorn, stag, wild cat, badger, fox, and horse.

Previous to this post-Roman occupation of the caverns, there seems to occur a long blank period, as far as man, at any rate, is concerned; for no distinct traces of Neolithic times have been

met with, no relic of the age immediately preceding that of written history; in the hard stalagmitic breccia which separates the surface-soil from all below it we at once meet with the implements of Palæolithic man, and the bones of the Pleistocene mammalia. Throughout the breccia, and in the various beds of cave-earth and red sand below it (see figs. 2 and 3), a vast quan-

FIG 2



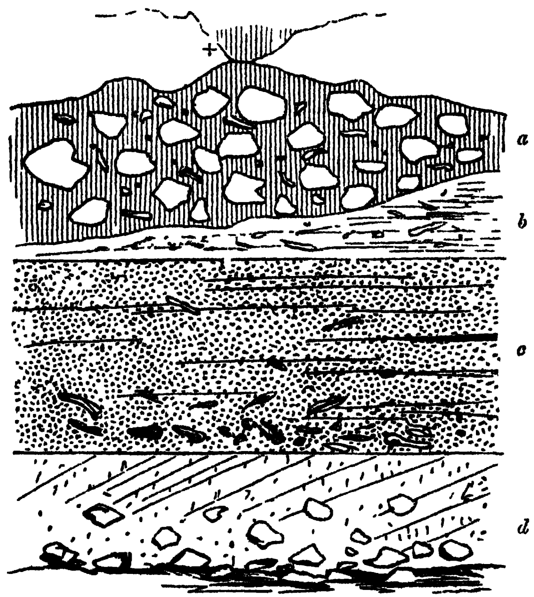
SECTION IN THE ROBIN HOOD CAVE

a Surface soil and thin breccia 2–3 in
b Cave-earth with flint and quartzite implements teeth bones angular limestone fragments, and charcoal 3 ft
c Red Sand with laminated clay, few bones 3 ft
1 Fox Hole ?

tity of bones and teeth of animals were found, affording to the imagination a vivid picture of the abundant wild fauna of the district. About twenty different species have left their remains here, some of them, such as the horse, the rhinoceros, and the hyæna, in remarkable numbers. Is it asked how all these bones got entombed here, we have to point in the majority of cases to the hyænas. These savage animals would, during the absence of man, be the lords of the caves, to which they would drag their numerous victims, and where they would devour them. The majority of the bones of the other animals, and even of the

hyænas themselves, are in fact covered with tooth scorings, which have been shown to be identical in character with those made by hyænas at the present day; and even such powerful animals as the rhinoceros and the mammoth might not unfrequently fall a prey to the hyænas, who would attack them when enfeebled by disease, accident, or age, or even when young they would sometimes be overcome by sheer force of numbers; or the hyænas, often hunting in packs, would occasionally drive them over the precipices, and fall upon them as they lay crippled at

FIG. 3.



SECTION IN THE ROBIN HOOD CAVE.

× Stalagmite uniting breccia with roof.
a. Stalagmitic breccia, with bones and implements, 18 in. to 3 ft.
b. Cave earth, with bones and implements of variable thickness.
c. Middle red sand with laminated clay at base, containing bones, 3 ft.
d. Light-coloured sand, with limestone fragments.

the bottom. In the Creswell caves, as in so many other of the British ones, the remains of hyænas, representing individuals of all ages, have been found, from the young cub just cutting its teeth to the veteran who has little of them left save the well-ground stumps. The species of hyæna thus found is the *Hyæna crocuta*, almost, if not quite, identical with the Spotted Hyæna now met with only in South Africa. The more common Striped Hyæna has also been met with in caves, but not in England.

Amongst the larger beasts of prey found at Creswell are the lion and the panther. The cave lion only differed in size from that of the present day. Like most of the wild animals of the Pleistocene age, it was larger and more powerful. Throughout Europe, from Italy in the south to the wilds of Yorkshire in the north, the lion was commonly met with, although it is now found only in Africa and in parts of Asia; but there is some evidence that it was still existing in south-eastern Europe as lately as the first century of the Christian era. One of the most remarkable animals that appears to have once inhabited middle as well as southern England was a large feline species that must have been a terror to its weaker contemporaries. This was the *Machairodus latidens*, a beast armed with teeth that have been not inaptly compared to sabres, the canines being thin and recurved blades, with serrated edges, of the most formidable appearance. The remains of this animal, which have been met with in some abundance in France, until it was discovered in the Robin Hood's cave, had only twice before been found in England—in Kent's Hole, in Devonshire, where a few teeth occurred in conjunction with other Pleistocene bones. At Creswell only one canine has been found, possibly brought there by a human hand, but not improbably also denoting the occurrence of the Machairodus as a contemporary of the lions, bears, and hyænas of the surrounding country.

Enough bones and teeth of bears have been discovered in the Creswell caves to denote the existence of at least two large species, the great grizzly (*Ursus ferox*) and the brown bear (*U. arctos*). The first of these is identical with the present species familiar to the North American fur-hunters; and the smaller brown bear is not uncommon in many parts of Europe. It was still living in Scotland as recently as A.D. 1057, when the last specimen is said to have been killed. Another bear, now extinct, common to caves—the huge cave bear (*U. spelæus*)—has not been certainly met with at Creswell, but is common in many other caverns, both in England and abroad.

Remains of wolves and foxes occur in all the Creswell caves; some of the former denoted very large animals, and have been thought by Professor Busk to have been possibly allied to the arctic, or North American, rather than to the existing European species. If this be the case it will then have been a fit companion for such animals as the arctic fox, the glutton, and the reindeer, all of which have been found in British caverns, the Arctic fox having been recognized for the first time in this country in the remains from the Pin Hole cave at Creswell; it appears, however, to have abounded formerly in Belgium, and even as far south as Switzerland, and to have been well known to the Palæolithic hunters, who have skilfully engraved its

likeness on some of their bone implements. It is also from the Pin Hole that the only trace of the glutton, as occurring at Creswell, has been derived. This animal is the Wolverine of the North Americans. It also lives in Siberia, and its bones have been found in several British caves, as well as in those of Belgium. Its presence is, as has been observed, significant of the prevalence of a severe climate. In Kamtschatka, where it is sometimes found, its skin is so highly prized by the natives that they say the heavenly beings are clothed in it.

The principal ruminants whose bones and teeth have been found at Creswell are the great ox, or urus; a lesser species, known as the Celtic shorthorn (*Bos longifrons*); the bison, and various deer, the most prominent of which are the reindeer and the megaceros, sometimes called the Irish elk. The huge urus (*B. primigenius*), the bones of which were found in the Pin Hole, was not only common in Pleistocene times, but was also known to the Romans, and, except in size, there is no real difference between it and the existing ox: the wild cattle of Chillingham, in fact, are supposed by some writers to be its direct descendants. The size of this animal in the Pleistocene period was, however, immense, being as much as six feet high, and from eleven to twelve feet long. Professor Owen has remarked that "the extensive range it had, when in former times it wandered at will in vast herds over the whole of England, and the abundant food it would find, tended to its development, whilst after the submergence of the old Pleistocene lowlands it would have had a harder battle to fight, and would thus have degenerated. This, and the hostility of man, may help to account for the greater size of nearly all the Pleistocene mammalia, as compared with their descendants." It has been observed that the Urus seems to have held its ground after the elephants, rhinoceroses, hyænas, and other animals had retreated southwards, although in Roman times it was probably scarce; still, we read of its existence in a wild state, together with the bison, as late as the close of the eleventh century, near Aachen, and in Poland even up to the sixteenth century.

In the red sand bed of the Creswell caves remains of the bison were tolerably numerous. This animal, which still lives in North America as well as in the forests of Lithuania, was a contemporary of the Urus, and with it disappeared from history; it does not seem to have been known in historical times in Northern Europe.

Reindeer remains, teeth, bones, and broken antlers—the bones and antlers, with few exceptions, having been gnawed by the hyænas—were very abundant at Creswell, both old and young animals being well represented. The reindeer seems to have ranged throughout the greater part of Europe, and with other

Arctic animals was hunted by the ancient cave-dwellers as far south as the Pyrenees. Contemporary with these animals was the great Irish elk (*Cervus megaceros*). This huge deer, the remains of which are not unfrequent in caves, had also a wide range, from Ireland and England, through France, Germany, and Central Italy. The bones of several individuals, one of them being of unusually large size, were found at Creswell.

One of the most abundant animals, the bones of which were found in the Creswell caves, were those of the small Pleistocene horse, and it would doubtless have formed a staple article of food, not only to the hyænas and other carnivora whose teeth-marks are so common on its bones, but also to the early cave men, who did not share the prejudice or superstition against the use of horseflesh which prevailed in later times. No trace of the musk ox, which is not uncommon elsewhere, has been found in these caves, although it may have been an inhabitant of the neighbourhood. The animals which it is perhaps the most difficult for us to realize as having been contemporaries with man in England, are the woolly rhinoceros (*R. tichorhinus*) and the mammoth (*Elephas primigenius*). Yet few facts are more certain than that primeval man must have constantly encountered these creatures as he went out on his hunting expeditions. Three species of rhinoceros inhabited England during the Pleistocene period. The one most frequently met with is the two-horned woolly rhinoceros, which, besides being hairy, like the mammoth, had also a smooth skin, contrasting in this with the existing species with its thickly-folded covering. It was apparently fitted to undergo a far severer climate than any of its living relatives. Its remains are found very widely spread; some are imbedded in the frozen mud of the Lena in Siberia, and from caves and gravel beds over a large part of Europe its bones have been obtained; these as well as teeth found in the Creswell caves show that this animal was plentiful in the neighbouring country, and the gnawed condition of its bones shows that it fell a frequent prey to the hyænas, whilst a large number of milk teeth found show that many young individuals were present. This was also the case with the next animal to be noticed, the mammoth. All three of the caves explored at Creswell have yielded teeth and bones of the mammoth, some of the former being from adults, but very many were milk teeth: this is what we should naturally expect, as it is hardly likely that hyænas would often obtain the mastery of the full-grown animal unless it happened to be maimed or otherwise enfeebled. The mammoth, with its shaggy hair and huge recurved tusks, was doubtless, like the woolly rhinoceros, capable of enduring great extremes of cold; its remains have also been found frozen at the Lena in so fresh a condition

that its flesh was eaten by the dogs and wolves. It is said that the Leachow islands off north-east Siberia were one mass of the bones of the mammoth, whole cargoes of ivory having been exported thence for the greater part of a century. Indeed, the number of mammoths inhabiting Northern Europe must have been prodigious. In the midst of the Channel between Dover and Calais a mass of their bones has been dredged up; and thousands of their teeth have been obtained in a similar manner off the coast of Norfolk. The range of the mammoth was very wide, as not only in Siberia and in these islands have its remains been discovered, but also in Russian America, and in Europe as far south as Spain in the west and Rome in the east. Two other elephants besides the mammoth were living with it in this country, but their remains are not so common, and they have not been found at Creswell. One of them, the *E. antiquus*, had a range nearly as great as that of the mammoth.

The other animals which existed during the Pleistocene period, and whose remains have been obtained in the Creswell caves, do not call for any very special notice; amongst them were hares and voles, the bones of both which are very plentiful. The hare was doubtless a common article of food with the early inhabitants.

We must now turn to the evidences of man's existence as a contemporary of all these animals, as proved by the explorations at the Creswell caves. That man was present during the early Romano-British period we have already seen; but an examination of the ossiferous breccia of the Robin Hood and Church Hole caves, as well as of the various beds sealed up under it, has proved that man was also, at any rate, an occasional occupant of these caves during the long antecedent Pleistocene times, for although we do not find human bones, various implements and weapons of undoubted human workmanship occur in intimate connection with the remains of the extinct mammalia.

It is sometimes asked how it is that human bones seldom, if ever, are found in these earliest deposits? It is surely easily accounted for by the consideration that the proportion borne by the men of that period to the wild beasts would be but as one to many thousands, and it would be an extraordinary thing were many human bones present. But no one can now seriously question the human origin of the many and various implements of the Pleistocene age; it is true that many of them are rude in the extreme—so rude that individual specimens taken by themselves might make us hesitate before deciding upon their origin; but mingled with these are others far more elaborate in workmanship, and besides the stone implements which give to

this age of man the name Palæolithic, there have been found numerous specimens of arrow-heads, awls, needles, harpoons, &c., made of bone and reindeer antlers. Some of the bone implements are carved with not unskilful ornamentations, figures of animals not being unfrequent, and amongst these are well-executed engravings of horses, the reindeer, the arctic fox, and even of the mammoth, most clearly proving that the men who executed them must have been familiar with the forms of these animals, and we can therefore only come to the conclusion that they were contemporaries. Such bone implements and specimens of primitive art, as well as implements of stone, have been met with in the caves of France, Belgium, and Switzerland. A few bone tools, and notably some harpoon heads, have been found in this country in Kent's Hole.

Looking now at the Creswell caves, the sections of their floors show us a distinct series of beds of sand, earth, and breccia, accumulated upon the original floor of the caverns. In each of these deposits we have distinct traces of human occupation, and what gives additional interest to them is, that they bring before us very clear evidence of an advancing civilization: as we rise from the lower to the upper beds, we have a most decided progress shown in the character of the implements derived from the several deposits.

In the bottommost bed of red sand (see sections, figs. 2, 3) mingled indiscriminately with the bones and teeth of the various animals already described, occurred tools of the very rudest description, manufactured out of the quartzite pebbles which abound in the district. Some of these have been used as hammers, the proof of which is seen in their bruised and chipped ends; other pebbles had been split into rough flakes (figs. 4–6), which may have served various purposes as knives, choppers, and scrapers for the preparation of skins. Implements as rude as these are said to be still in use amongst the Shoshone and Wyoming Indians, and equally rude ones have been found at the Cape of Good Hope. We may picture to ourselves a race of savages who, in pursuit of the horse, the reindeer, and even of the mammoth and other animals we have spoken of, visited the neighbourhood of Creswell and made use of its caves as convenient dwellings or sheltering places, driving off for a time the hyænas, who would return again to their dens during the absence of these primitive hunters. How long a time elapsed during the accumulation of each bed in these caves we have no possible means of judging, but as we pass upwards from the red sand into the succeeding cave earth, we not only find similar quartzite implements, but also a few others made from flint. Still there was in these latter none of that perfection of workmanship arrived at by the later users of that material;

apparently a lengthy apprenticeship was required before the skill to adapt even this more tractable stone could be acquired. It was in the upper part of the cave earth and in the breccia that a higher class of work made its appearance in these beds, accompanying, be it observed, the remains of the Pleistocene

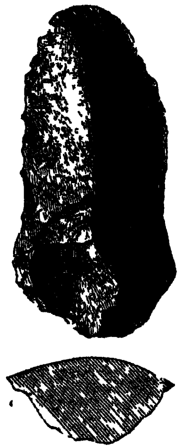
FIG. 4.



QUARTZITE HACHE, HALF NATURAL SIZE.

a. Section. Cave earth.

FIG. 5.



QUARTZITE FLAKE, × ½.

a. Section. Cave earth.

FIG. 6



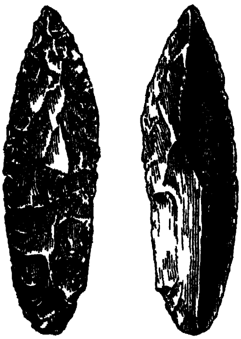
OVAL QUARTZITE IMPLEMENT, × ½.

a. Section. Cave earth.

mammalia, and numerous implements, some of quartzite, others of flint, and two or three of clay ironstone (fig. 7) were found, and with these were also fragments of charcoal, showing that man was in the habit of using fire. Some of the quartzite and also the ironstone implements were, it has been observed, "of the same form as those which have been discovered in the river gravels of Brandon, Bedford, and Hoxne, and which occur in those of France, from St. Acheul, near Amiens, as far as the district round Toulouse, and always in association with the mammoth, reindeer, and woolly rhinoceros. Others with curved hatchet edges, notched by use, were choppers, like those met with in the bone caves of Dordogne under very similar circumstances as at Creswell, by MM. Lartet and Christy;

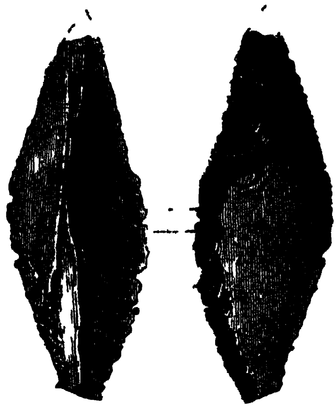
and the natural surface of the pebbles from which they were made was left untouched, so that they might be conveniently

FIG. 7.



OVAL INSTRUMENT OF CLAY-IRONSTONE, × ½.

FIG. 8.



LANCE HEAD OF FLINT, × ½
Breccia.

grasped by the fingers. There were also many triangular flakes intended for cutting purposes, and scrapers intended for the

FIG. 9.



FLINT SCRAPER, × ½
a. Section. Cave earth.

FIG. 10.



FLINT-BORER. (FULL SIZE).
Breccia

preparation of skins. The implements of flint also were very numerous (figs. 8–10): flakes, scrapers, beautifully-chipped lance-heads, of the same form as those found in the bone caves of Wookey Hole, near Wells, Kent's Hole, near Torquay, and in

France, at Solutré; borers and awls, in some cases worn by use, as well as small oval forms bearing a close resemblance to the carefully chipped stonecutters used by the Eskimos for

Fig. 11.



POINT MADE OF ANTLER (full size).
Cave earth. Robin Hood Cave.

Fig. 12.

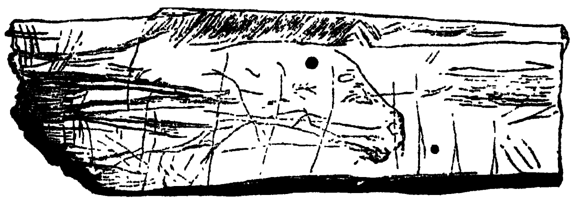


ROD OF REINDEER ANTLER;
Church Hole Cave.

planing wood. Some of the flakes had obviously been let into a handle of wood, or some other perishable material, which protected one edge while the other was completely worn away. Articles of bone and antler were also met with—bone awls, a well-finished bone needle, and cylindrical rods of antler, which may have been portions of the points of spears" (figs. 11, 12). One of the most interesting discoveries made in this part of the floor of the Robin Hood cave was a fragment of rib having engraved upon it the head and forepart of a horse (fig. 13). This is the only instance in which a trace of what we may term Palæolithic high art has been met with in this country, and it is of extreme interest, as correlating these caves with those of the Continent in which similar works have been found; engravings of the reindeer, of the arctic fox, and even of the mammoth, as has been observed, having been obtained from the caves of France, Switzerland, and Belgium. We thus have brought before us in the Creswell caves a most important chapter in the history of early man, a sequence of implement-bearing beds showing a progress in civilization such as has "not been observed in any other series of caverns in any part of the world." We learn that even the Palæolithic age of man has its periods;

the earliest, that in which man was a savage in the very lowest state of culture, with such tools only as he could roughly fashion out of the nearest pebbles, a single flake or two struck from their sides being sufficient to adapt them for their respective uses, whether as axes, or hammers, or scrapers. Then came the discovery of flint as a more tractable material, and also giving sharper cutting edges; and flint tools were gradually improved, and bone and other materials were also made use of. The men who used the more perfectly shaped implements, especially those made of bone, must have been in a higher state of civilization than those who had but a broken pebble; and the discoveries at Creswell, where the more finished type of implements is found above the ruder, show that the more civilized man succeeded the earlier savage race, or else that this latter, in the course of ages, improved in the arts of tool-making, and learnt not only to shape the flint

FIG. 13.



FRAGMENT OF RIB WITH ENGRAVING OF HORSE (full size).
Cave earth. Robin Hood Cave.

more elaborately, but also to make use of bone for domestic and other purposes. What these Palæolithic men were like we have no certain means of knowing, but it has been shown by a careful comparison of their implements and habits of life, so far as these latter can be ascertained, that they may not improbably have been of the same race as the existing Eskimos, a hardy race of hunters and fishermen, who have in the long course of ages been driven gradually, in company with the reindeer and other arctic animals, to more northern climes. It is strange for us to realize that these men once speared their fish in the ice-bound rivers of England and France, roaming with the changing seasons as far to the south as Switzerland, and to the north as Derbyshire and Yorkshire in England, in pursuit of such animals as the horse, reindeer, urus, bison, and even the rhinoceros and mammoth. It is strange indeed to realize all the wondrous changes of climate, physical geography, and of human history, that have taken place since that remote past, when man, the hunter and fisherman, made his home in the caves, and wandered through the far-extending forests and swamps of these countries.

We are carried back in thought to days when the Scottish, English, and Welsh highlands were bound in an icy raiment; when large glaciers descended from the mountain flanks into the valleys, where the reindeer, the musk ox, the glutton, and the arctic fox found a congenial home, and where also the animals of warmer climes were constant visitors: days when England was united to Europe, and even the hippopotamus could find its way, unhindered by ocean barriers, into the rivers of Yorkshire. We may perhaps picture to ourselves conditions somewhat like those yet prevailing on the western coast of South America, where the glacier descends into plains of almost tropical heat: and we can understand how, under such circumstances, the severity of an arctic winter would force the animals of the northern regions to migrate even as far south as the Pyrenees, whilst the returning heat would tempt such animals as the lion, the leopard, the hyæna, and the hippopotamus as far to the north as central England. We thus find commingled in one common grave, bones in a perfectly similar state of preservation, evidently lying where they were first deposited—a clear proof of contemporaneity of the representatives of faunas which are now so widely separated. Strangely different must have been the England of those days. Through the centre of that region now occupied by the German Ocean flowed a great river, rising far south in the Alps, and receiving among its tributaries the Thames and the Humber; from its banks probably stretched extensive forests and grassy plains, whilst on the other side of England similar plains and forest tracts occupied what is now sea. Through this country the various animals we have spoken of all wandered at will—deer and oxen, and horses, rhinoceroses, and elephants, and the savage carnivora; whilst amongst them Palæolithic man hunted and fished, and fought for his life. Gradually the conditions of the country changed, may be after a period of intense cold, accompanied by physical change, during which the Pleistocene men and animals gradually passed away, or migrated; a more genial climate prevailed, and with it came also a more civilized race of men, the men of the Neolithic period, bringing with them domesticated animals and the appliances of a higher culture. Age after age has thus passed by, and tribe after tribe has pushed on from far distant homes to people new lands, and the newcomers have even displaced the earlier ones. Civilization has replaced little by little the rude contrivances of old by the varied implements which subserve man's many wants in these more artificial days. The rough tools and weapons of stone, bone, or horn gave place to others of bronze, and then of iron. The cave was forsaken for the hut, in its turn to be left for the house of brick or stone; the wild hunter, fisherman, and shepherd has been followed by the civilized

man of to-day, before whom the wild beasts of the caves and the forests have disappeared, some for ever, others only to be found again far from the daily haunts of man. Thus may we trace out the stages of human progress. "Man alone," says Professor Nilsson, "can make progress; he alone can throw aside his first rude weapons, alter them according to his improved cultivation and more refined activity. Man, that he might become the most powerful, was made at first the weakest. Through that alone he was induced to develop his higher talents, for it was not by bodily strength but by the power of the mind that he was to be the king and lord of the earth."

METEORITES AND THE ORIGIN OF LIFE.

By WALTER FLIGHT, D.Sc., F.G.S.,

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THE question which has so often been raised, How did life originate on our earth? has again been brought before the consideration of the scientific world by Professor Allen Thomson, in the Presidential address delivered at the Plymouth meeting of the British Association during the present autumn. One explanation to which he refers is that which formed a prominent feature in the address of a former occupant of the Presidential chair, Sir William Thomson, who six years ago suggested as a possible solution of this great question that the germs of life might have been borne to our globe by the meteorites which are scattered through space, and which from time to time fall upon the surface of our planet. If, he maintained, we trace back the physical history of our earth, we are brought to a red-hot melted globe on which no life could exist. The earth was first fit for life, and there was no living thing upon it. Can any probable solution, consistent with the ordinary course of nature, be found to explain the problem of its first appearance? When a lava stream flows down the side of Vesuvius or Etna, it quickly cools and becomes solid, and after a few weeks or years it teems with vegetable and animal life, which life originated by the transport of seed and ova and by the migration of individual living creatures. When a volcanic island emerges from the sea, and after a few years is clothed with vegetation, we do not hesitate to assume that seed has been wafted to it through the air, or floated to it on rafts. Is it not possible—and if possible, is it not probable—that the beginning of vegetable life on the earth may be similarly explained? Every year thousands, probably millions, of fragments of solid matter fall upon the earth. Whence came they? What is the previous history of any one of them? Was it created in the beginning of time an amorphous mass? The idea is so un-

acceptable that, tacitly or explicitly, all men discard it. It is often assumed that all, and it is certain that some, meteorites are fragments severed from larger masses and launched free into space. It is as sure that collisions must occur between great masses moving through space as it is that ships, steered without intelligence directed to prevent collisions, could not cross and re-cross the Atlantic for thousands of years with immunity from such catastrophes. When two great masses come into collision in space it is certain that a large part of each of them is melted; but it appears equally certain that in many cases a large quantity of *débris* must be shot forth in all directions, much of which may have been exposed to no greater violence than individual pieces of rock experience in a landslip or in blasting by gunpowder. Should the time when this earth comes into collision with another body, comparable in dimensions to itself, be when it is still clothed, as at present, with vegetation, many great and small fragments carrying seed and living plants and animals would undoubtedly be scattered through space. Hence and because we all confidently believe that there are at present, and have been from time immemorial, many worlds of life besides our own, we must regard it as probable in the highest degree that there are countless seed-bearing meteoric stones moving about through space. If at the present instant no life existed upon this earth, one such stone falling upon it might lead to its becoming covered with vegetation. "I am fully conscious," he concludes, "of the many scientific objections which may be urged against this hypothesis, but I believe them to be all answerable. . . . The hypothesis that life originated on this earth through moss-grown fragments from the ruins of another world may seem wild and visionary; all I maintain is that it is not unscientific." *

Sir William Thomson's views, thus plainly set forth, did not fail to attract adverse criticism. Before we proceed to consider the comments which his hypothesis called forth, we may call the reader's attention for a short time to speculations in the same direction which have appeared in the writings of scientific men in France and Germany.

First, we must refer to a remarkable passage in the great work of Count A. de Bylandt Palstercamp, on the Theory of Volcanos † He wrote in 1835, at a time when Laplace's theory that meteorites were hurled at us from lunar volcanoes was still generally received, and this will account to some

* "Address of Sir William Thomson, Knt., LL.D., F.R.S., President." London: Taylor and Francis. 1871. P. 27.

† "Théorie des Volcans. Par le Comte A. de Bylandt Palstercamp." Paris: Levrault. 1838. Tome i. p. 95.

extent for the source of the cosmical masses of which he treats. What is mainly worthy of notice is their character, of carriers of the faculty of organization, which he attributes to them. In the chapter intituled "Principe d'après lequel le premier développement de notre globe peut s'être effectué?" he writes: "It may be a matter of curiosity, but it is in nowise necessary, that we should know on what principle or from what organized body the great mass of our globe has been derived; it is sufficient for us that we exist in a manner where everything is perfectly organized, at least in so far as the aim of our existence is concerned. Many scientific men have exercised their imagination on this problem without being able to come to any definite decision. Some maintain that the nucleus of our globe was a fragment of a body which in its cosmical path had dashed itself into fragments against the sun, which the very close proximity of some comet to that star gives grounds for believing. Others suppose us to be a vast aerolite thrown off from the sun himself* with a force proportional to its mass, to a zone where the motion is determined in accordance with the laws of reciprocal attraction, and that this fragment carried in itself the germ of all that organization which we see around us, and of which we form a part. (*Que cet éclat portait en lui le germe de toute cette organisation que nous observons ici et dont nous faisons partie.*) They suppose the satellites to be small parts or fragments detached from the chief mass by the violence of the rotation at the time it is hurled forth, or by the excessively high original temperature, increased by the fall, which produced a very violent dilatation of the matter, and severed some portions from it. These aerolites, it is said, by way of comparison, contain within them the principle common to the body whence they have been derived, just as a grain of seed carried by the wind is able to produce at a remote distance a tree like its prototype, with such modifications only as are due to soil or climate."

In the spring of 1871 Professor Helmholtz delivered at Heidelberg and at Cologne a discourse on the origin of the solar system, which he printed in the third collection of his interesting "Populäre wissenschaftliche Vorträge," published last year.† He directed attention on that occasion to the facts that meteorites sometimes contain compounds of carbon and hydrogen, and that the light emitted by the head of a comet gives a spectrum which bears the closest resemblance to that

* He alludes here in a note to the theory held by Laplace and others.

† "Populare wissenschaftliche Vortrage. Von H. Helmholtz." Braunschweig: Vieweg und Sohn. 1876. Drittes Heft. p. 135.

of the electric light when the arc is surrounded by a gaseous hydrocarbon. Carbon is the characteristic element of the organic compounds of which all things living are built up. "Who can say," he asks, "whether these bodies which wander about through space may not also strew germs of life where a new heavenly body has become fitted to offer a habitat to organized creatures?" The hypothesis, in the form set forth in 1871 by Professor Helmholtz and Sir William Thomson, was vigorously handled by Zöllner, of Leipzig, whose work, "Ueber die Natur der Cometen," appeared in the following year. In the *Vorrede* of his book he passes his countryman by unmentioned, but declares Sir William Thomson's proposition to be unscientific, and that in a twofold sense. In the first place, he maintains it is unscientific in a formal or logical sense, in that it changes the original *simple* question, Why has our earth become covered with organisms? into a second, Why had that heavenly body the fragment of which fell upon our planet become covered with vegetation, and not our earth itself? "If, however," he adds, "bearing in mind an earlier dictum,* we regard inorganic and organic matter as two substances from all eternity diverse, just as in accordance with our present views we consider two chemical elements to be diverse, such an hypothesis as that now advanced must be at variance with the destructibility of organisms by heat which experience has taught us."

"Again," contends Zöllner, "the hypothesis in its *material* bearing is unscientific. When a meteorite plunges with planetary velocity into our atmosphere, the loss of *vis viva* arising from friction is converted into heat, which raises the temperature of the stone to a point where incandescence and combustion take place. This, at all events, is the theory at present generally held to explain the phenomena of star-showers and fire-balls. A meteorite, then, laden with organisms, even if it could withstand the sundering of the parent mass unscathed, and should take no part in the general rise of temperature resulting from this disruption, must of necessity traverse the earth's atmosphere before it could deliver at the earth's surface organisms to stock our planet with living forms." †

Helmholtz did not long delay in replying to Zöllner's criticism on this question. An opportunity occurred during the publication, in the following year, 1873, of the second part of the German translation of Thomson and Tait's "Handbook of Theoretical Physics." The preface contains Helmholtz's

* "Dead matter cannot become living matter unless it be subject to the influence of matter already living."

† "Ueber die Natur der Cometen. Von J. C. F. Zöllner." Leipzig: Engelmann. 1872. p. 24.

answer.* He points to the fact, confirmed by numerous observers, that the larger meteoric stones, during their transit through our atmosphere, become heated only on the outer surface, the interior remaining cold—often very cold. Germs which may happen to lie in the crevices of such stones would be protected from scorching while travelling through the air. Those, moreover, which lie on or near the surface of the aerolite would, as soon as it entered the upper and and most attenuated strata of our atmosphere, be blown off by the swift and violent current of air long ere the stone can rend those denser layers of our gaseous envelope where compression is sufficiently great to cause a perceptible rise of temperature. As regards that other point of debate, referred to by Thomson only, the collision of two cosmical masses, Helmholtz shows that the first result of contact would be violent mechanical movement, and that it is only when they begin to be worn down and destroyed by friction that heat would be developed. It is not known whether this may not continue for hours or days, or even weeks. Such portions as at the first moment of contact are hurled away with planetary velocity may consequently be driven from the scene of action before any rise of temperature may have taken place. "It is not impossible," he adds, "that a meteorite or a swarm of meteorites, in traversing the upper layers of the almosphere of a heavenly body, may either scatter from them or carry with them a quantity of air containing unscorched germs. These are possibilities which are not yet to be taken as probabilities; they are questions which, from the fact of their existence and range, are to be kept in sight, so that, should a case arise, they may receive an answer either by actual observations or by some conclusive deduction." It should be mentioned here that these views of Helmholtz's are also to be met with in a supplement to his lecture on the origin of the solar system.

In tracing the gradual development of this important controversy we now arrive at the present year, and proceed to discuss the allusion made to it by Professor Allen Thomson in his address at Plymouth. The difficulty regarding the origin of life is, he considers, not abolished, but only removed to a more remote period, by the supposition of the transport of germs from another planet, or their introduction by means of meteorites or meteoric dust; for, besides the objection arising from the circumstance that these bodies must have been subjected to a very high temperature, we should still have everything to learn as to the way in which the germs arose in the

* "Handbuch der theoretischen Physik. Von W. Thomson und P. G. Tait." Uebersetzung von H. Helmholtz und G. Wertheim. Braunschweig: Vieweg und Sohn. 1874. Erster Band. Zweiter Theil. 11.

far distant regions of space from which they have been conveyed. At one of the Sectional meetings, a few days later, Sir William Thomson made these observations the text of a further communication on the now well-worn subject. He desired to limit the discussion to the bare dry question, Was life possible on a meteorite? The hypothesis which was to explain the bringing of life to our earth did not pretend to explain the origin of life, and he would not attempt to offer an explanation of the origin of life. The three questions which presented themselves were these: Was life possible on a meteorite moving in space? Was life possible on a meteorite while falling to the earth's surface? and, Could any germs live after the meteorite had become imbedded in the earth? A meteorite may be exposed to great heat before it reaches the earth; whether or not life on that meteorite would be destroyed by that heat was dependent on the duration of exposure. If a meteorite traversed space with the same side always exposed to the sun that side would be strongly heated, the other would be cold; if it spun round at a uniform rate all its surface would be of one uniform temperature; and if it rotated once per hour it would have a high temperature on one side and be as cold as ice on the other. The whole or part of the surface of a meteorite might afford a climate suitable to some living forms, destructive to others. When the moss-covered stone enters the atmosphere the germs upon its surface would be torn off long before the stone became heated, and in a few years they may settle down on the earth, take root, and grow. But were the germs of the exterior destroyed by heat, there might still be vegetable life in the interior. The time occupied by a stone in its passage through the air would not be more than twenty or thirty seconds at the outside, so that the crust might be fused, while the interior might have a moderate temperature, and anything alive in it would fall to the earth alive. Sir William Thomson concluded by remarking that after the collision of cosmical masses fragments must be shot off, some of which must certainly carry away living things not destroyed by the shock of the collision, and he did not hesitate to maintain, as a not improbable supposition, that at some time or other we should have growing on this earth a plant of meteoric origin. At this particular stage of the debate (so we are informed by "The Western Morning News") some one attending the meeting of the Section introduced the Colorado Beetle, and this was held to be irresistibly funny; then someone else got up and said he was an Irishman, which was judged to be even funnier still. At length another speaker arose to breathe the hope that when Papa Colorado Beetle dropped down on a meteorite he would leave Mamma Colorado Beetle

behind, which was felt to be far and away the funniest thing of all. Some of the Associates, however—men who had not yet learned to know the length and depth of scientific "wit"—began to feel uneasy; and although a gallant effort appears at this juncture to have been made to win back their confidence by assuring them that meteorites really do not contain organic matter of any kind, the Section was not to be comforted till the telephone was set a-going But to return.

Nothing bearing the semblance of a plant or even of its seed has as yet been met with in a meteorite; nor have any of the masses which have fallen on our planet shown anything approaching the structure which distinguishes sedimentary rocks from those of a purely plutonic character. The occurrence, however, in them, or with them, of organic compounds, of compounds of carbon and hydrogen, which it is hard to suppose could owe their existence to any other agency than that of life itself, and which represent the final stage previous to their final destruction, has now been so frequently noticed that I have put together in chronological order what information in this direction from a "world ayont" the meteorites have brought to us.

1806. *March 15th*, 5 P.M—Two stones, weighing together six kilogr., fell at Alais, Dép. du Gard, France. They have the appearance of an earthy variety of coal; the colour of the crust is a dull brownish-black, so is that of the interior. The structure is very soft and friable. When heated it emits a faint bituminous odour. It was examined at the time of its fall by Thénard and a Commission appointed by the Institute of France. The French observers found it to contain 2·5 per cent. of carbon; while Berzelius, in 1834 estimated the amount of carbon present to be 3·05 per cent. In 1862 Roscoe submitted this meteorite to a very thorough investigation. He found the carbon present to amount to 3·36 per cent. Ether dissolved 1·94 per cent. of the stone; the solution on evaporation left crystals which have an aromatic odour, and a fusing-point of 114° C., and which sublime on the application of heat, leaving a slight carbonaceous residue. The crystals really appear to be of two kinds: *acicular* crystals, which are sparingly soluble in absolute alcohol, but are readily taken up by ether, carbon disulphide, turpentine, and cold nitric acid, and dissolve in cold sulphuric acid, striking a brown colour; and *rhombic* crystals, which dissolve in ether and carbon disulphide, but are unaffected by cold nitric acid, sulphuric acid, or turpentine. An analysis of 0·0078 gramme of the crystals soluble in alcohol, gave the following numbers:—

Sulphurous acid .	0,010	Sulphur . . .	0·005
Carbonic acid .	0·008	Carbon . . .	0 0022
Water . . .	0·003	Hydrogen . .	0·0003

The atomic ratio of carbon to hydrogen, then, is nearly 1 : 1, or that of the reddish-brown and colourless mineral resin könleinite, which occurs in crystalline plates and grains in the lignite of Uznach, in Switzerland. Kraus makes the fusing-point of könleinite 114° C.; it is slightly soluble in alcohol, but much more soluble in ether. Dr. Lawrence Smith, who has recently examined the Alais meteorite, arrives at the same results as Roscoe; and also that the carbonaceous ingredient of this meteorite resembles in all its physical characters those of a substance which he obtained from the graphite of the Sevier-County meteoric iron, to which I shall presently refer.

1838. *October* 13*th*, 9 A.M.—At the hour mentioned a great number of large stones fell over a considerable area at Kold-Bokkeveld, seventy miles from Cape Town. Those which fell near Tulbagh are estimated to have weighed many hundred-weights. It is said that they were soft when they fell, but became hard after a time. This material has a dull black colour, and is very porous and friable. Harris, who analysed it in 1859, determined the presence of 1·67 per cent. of carbon, and somewhat more than 0·25 per cent. of an organic substance soluble in alcohol. This compound is described as possessing a yellow colour, and a soft resinous, or waxy, aspect. It readily fused with a slight rise of temperature, and when heated in a tube it was decomposed, emitting a strong bituminous odour, and leaving a carbonaceous residue. Some four years ago I was considering what should be done with a trace of this substance, so small in amount that it could not be removed from the vessel containing it. I was unwilling to throw away even so small a quantity of so precious a substance, so I drew off the neck of the flask and placed it in a dark cupboard of a room, the temperature of which, during the greater part of the year, is unusually high. In the interval this organic compound has sublimed, and is deposited on the higher parts of the vessel in colourless and well-defined crystalline plates.

1840.—During this year a large mass of meteoric iron was discovered in Sevier County, Tennessee, enclosing a large nodule of graphite. "It is," writes Dr. Lawrence Smith, "the largest mass of graphite which has come under my observation, and is perhaps the largest known." Its dimensions are 60^{mm} by 20^{mm} and 35^{mm}, and it weighs 92 grammes. Two grammes of this nodule were reduced to powder and treated with ether, and the liquid on evaporation left a residue weighing 15 milligrammes, and possessing an aromatic, somewhat alliaceous, odour. It consisted of long colourless acicular crystals, others which were shorter, as well as some rhomboidal crystals and rounded particles. This extracted substance melted at about 120°C. When heated in a tube closed at one end it melts and

then volatilizes, condensing in yellow drops, and leaving a carbonaceous residue. Dr. Lawrence Smith believes that the three elements, carbon, hydrogen, and sulphur, which they contain, may be in combination, and he has named the meteoric sulphohydrocarbon "celestialite."

1857. *April* 15*th*, 10.11 P.M.—A brilliant detonating meteor was observed at this hour over Kaba, S.W. of Debreczin, Hungary, and a meteorite weighing 4 kilogr. was found on the following morning imbedded in the hard surface of a road close by. The crust is black, and the mass of the stone dark grey; throughout the structure black portions of the size of peas lie scattered, giving the stone a porphyritic character. Wöhler treated the stone with alcohol, which removed a white, apparently crystalline, substance possessing a peculiar aromatic odour. With ether it broke up into oily drops, and appeared to be decomposed into an insoluble fluid body and a soluble solid portion. The solid substance was obtained in a distinctly crystalline condition on driving off the ether. It volatilizes in air, fuses in a closed tube, and is decomposed when greater heat is applied, a fatty odour being observed, and a black residue left. The hydrocarbon is believed by Wohler to be allied to ozocerite or scheererite. When the powdered stone is heated in oxygen it turns of a cinnamon-brown colour This meteorite contains 0·58 per cent. of carbon.

1861.—The huge mass of meteoric iron discovered at Cranboune, near Melbourne, Australia, in 1861, encloses more or less rounded masses of carbon. They are pronounced by Berthelot, who has submitted some of the material to the most powerful oxidizing reagents, to resemble the form of carbon which separates from cast-iron on cooling rather than native graphite.

1864. *May* 14*th*, 8 P.M.—On this occasion more than twenty stones fell at Montauban, Tarn et Garonne, France, some of them being as large as a human head, and most of them smaller than a fist. The appearance which this meteorite exhibits closely resembles that of a dull-coloured earthy lignite. The masses are black and very friable, and fall to powder when placed in water; this is due to the removal of the soluble salts which cement the ingredients together. A shower of rain would have destroyed them. One hundred parts of this stone contain 5·92 parts of carbon itself, partly as a constituent of one organic compound, which Cloëz found to possess the following composition:—

Carbon	63·45
Hydrogen	5·98
Oxygen	30 57
	100·00

Berthelot endeavoured to reconstruct the body of which this is a decomposed product by means of hydriodic acid, and

obtained a considerable quantity of the hydrocarbon $C_{n}H_{n+2}$ analogous to rock-oil. The reduction takes place less readily in this case than in that of coal. Dr. Lawrence Smith finds the combustible portion of the material to amount to about 4·5 per cent.

1867.—This Indian meteorite, which fell at Goalpara about the year 1867 (the exact date is not known), was examined by Tschermak, who found it to contain 0·85 per cent. of a hydrocarbon. The quantity, though small, materially affects the general appearance of the stone; it can be recognized under the microscope as a smoky-brown, lustreless ingredient accompanying the fragments of nickel-iron. Of the 0·85 per cent. 0·72 is carbon and 0·13 hydrogen. Tschermak suggests that the luminous phenomena so often attending the fall of an aerolite and the "tail" left by many meteors and shooting stars may be due to the combustion of compounds of which carbon forms an important constituent.

1868. *July* 11*th*.—The curious meteorite of dull grey hue and loose structure which fell on this day at Ornans, Doubs, France, partly owes its dark colour to the presence of a hydrocarbon.

1869. *January* 1*st*, 12.20 P.M.—A most remarkable fall of stones took place on New Year's Day, 1869, at Hessle, near Upsala; it is the first aerolitic shower recorded to have taken place in Sweden. The meteorites have so loose a structure that they break in pieces when thrown with the hand against the floor or frozen ground. The most interesting feature of the Hessle fall is the association with the stones referred to of matter mainly composed of carbon. The peasants of Hessle noticed that some of the meteorites which fell on the snow near Arnö soon crumbled to a blackish-brown powder resembling coffee-grounds. Similar powder was found on the ice at Hafslaviken in masses as large as the hand, which floated on water like foam, and could not be held between the fingers. A small amount secured for examination was found under the microscope to be composed of small spherules; it contained particles extractible by the magnet, and when ignited left a reddish-brown ash. Heated in a closed tube it gave a small brown distillate. A quantity dried at 110°C. possessed the following composition:—

Carbon	51·6
Hydrogen	3·8
Oxygen (calculated)	15·7
Silicic acid	16·7
Iron protoxide	8·4
Magnesia	1·5
Lime	0·8
Soda and Lithia	1·5
	100·0

The combustible ingredient appears to have the composition $n\,C_6H_4O_2$. It was noticed on this occasion that the stones found in the same district with the carbonaceous substance, were, as a rule, quite round and covered on all sides with a black, dull, and often almost sponge-like, crust. The iron particles on the surface of the smaller stones were usually quite bright and unoxidized, as though the stone had been heated in a reducing atmosphere. Nordenskjöld, who examined them, expresses the belief that this carbon compound frequently, perhaps invariably, occurs in association with the meteorites, and he attributes its preservation in this case to the fall of the stones on snow-covered ground.

1870.—During this year the Swedish Arctic Expedition discovered in the basalt of Ovifak, near Godhavn, Island of Disko, Greenland, some enormous metallic masses which are generally regarded as blocks of meteoric iron. Like meteoric iron, they contain nickel and cobalt, but, unlike that iron, they are but slightly attacked by hydrochloric acid. The metal, moreover, when heated evolves more than 100 times its volume of a gas which burns with a pale blue flame, and is carbonic oxide mixed with a little carbonic acid; after this treatment the substance dissolves in acid, leaving a carbonaceous residue. The composition of this remarkable "iron," if we may call it by that name, has been found by Wöhler to be as follows:—

Iron	80·64
Nickel	1·19
Cobalt	0·40
Phosphorus	0·15
Sulphur	2·82
Carbon	3·67
Oxygen	11·09
	100·05

It appears to be a mixture of about 40 per cent. of magnetite with metallic iron, its carbide, sulphide, and phosphide, and its alloys of nickel and cobalt, as well as some pure carbon in isolated particles.

From all this we see though there is not a particle of evidence to prove the persistence of living germs on meteorites during their passage through our atmosphere, it is quite clear that the cosmical bodies, whatever they may have been, from which our meteorites were derived, may very probably have borne on their surface some forms of organized beings.

One objection which appears to have been raised to Sir William Thomson's theory was to the effect that germs could not exist without air; another that the low temperature to

which they would be exposed before entering our atmosphere would suffice to destroy life. Micheli, in his valuable *Coup d'œil sur les principales publications de Physiologie végétale*, refers to the researches of Uloth,* who found that twenty-four species of plants which had been placed in a cave in the centre of a glacier germinated after the lapse of six weeks. *Lepidium ruderale* and *sativum*, *Sinapis alba*, and *Brassica Napus*, had germinated; and at the close of four months other crucifers and some grasses and leguminous plants had germinated also. Haberlandt found that of a number of seeds which had been exposed for four months to a temperature of 0° to 10° the following species flourished: rye, hemp, vetch, pea, mustard, camelina, two species of clover, and lucerne. The influence of the withdrawal of air from seeds on their power of germination has also been studied by Haberlandt. He found that seeds after they had been placed *in vacuo* germinated as usual. A slight retardation was noticed in the case of the seeds of the oat, the beetroot, and a bean, which appear to require the air contained in their tissues. In three experiments 58, 32, and 40 per cent. of the seeds germinated.

* "Flora," 1875, No. 17.

REVIEWS.

SCEPTICISM IN GEOLOGY.*

THIS is a well-written little book, and is explanatory of its author's doubts regarding the doctrines of uniformity and continuity as elaborated by Lyell and Geikie. It "does not deal with the great and incontrovertible *truths* of Geology, but only with certain excrescences, which aim at proving the earth to have been fashioned by mechanical processes still going on." The author anticipates "rough usage" from certain quarters, but submits that the long array of his facts, together with his answers and objections to alleged facts, cannot be refuted. The criticisms of the author relate, he states, to "uniformity, or the operation of modern causes; the elevating power of earthquakes; erosion of rocks by rivers; unlimited denudation by atmospheric denudation, and the antiquity of man on the earth." He suggests that "enormous exaggerations have paved the way for erroneous conclusions, and that supposed analogy has been mistaken for evidence." After claiming the right to doubt, and stating the value of doubting in science, the author informs his readers that he has studied the writings of the dominant school, and investigated the earth's structure in this and other countries himself. The liberty of doubting is pleaded for rather unnecessarily, for if any set of men doubt, criticize, and protest against dogmatic authority, it is that of the modern school of Geology; and if the author had come amongst them, listened to the debates of the Geological Society, and read the current literature of the science during the last few years, he would have found that most of his crotchets are out of date, and that Lyell and Geikie—an antithetic combination of genius and common-place—are not so much followed as he imagines. Should he read the address of the present President of the Geological Society, he will find therein the generally accepted limitation of the Huttonian doctrine, and a protest against the dogma that the forces of old acted continuously in the same degree. It is not fair on the part of the author to saddle geology with a theory because it emanates from a man who has "written a book;" and if he had made the slightest inquiry among the professors of Geology in England, or had mixed amongst the rising school, he would have heard such a dictum as the following: "It is evident that the great mountain chains of the world are due in the first place to upheaval," very much derided. The

* "Scepticism in Geology." By Verifier. 8vo. London: John Murray. 1877.

least knowledge of geological theory would have saved our critic from the trouble of antagonizing the notion that mountain formation and that of the volcano are identical or analogous. Lyell stated that there is an intimate connection between the two classes of phenomena; and Elie de Beaumont, at least forty years ago, attributed mountain formation not to partial volcanic action, or a reiteration of ordinary earthquakes, but to the secular refrigeration of the entire planet. Dana, Mallet, and all advanced teachers, follow this theory. The author demurs to the present rise of land. There is no doubt that whilst there is evidence of the rise of land in Scandinavia during the post-glacial and during the historic period, it is not a continuous operation; but the fact that there is no positive evidence of the rise of land in Sweden at this moment does not militate against the well-observed facts cited by Lyell. All evidence is not of the demonstrative kind; if it were science would be dark enough; but there is truth in the Butlerian axiom that probable evidence may approach demonstrable and even moral certainty. With regard to rivers cutting down gorges in rocks, the author states that they cannot do it, and that they did not do it, the river course being the result of cracks, faults, and fissures. He protests against the limestone cliffs of Yorkshire and Derbyshire being created by "watery erosion." Now, supposing that he knows the difference made by geologists between cliffs and escarpments, he need not be astonished at being told that inland cliffs are not believed by geologists to be produced by watery erosion; and, indeed, he will find it taught that many deep valleys are in lines of fault, many in great cracks, without relative tangible displacement of the strata; and that the initiatory condition of some profound cañons was a fissure. With regard to the non-erosive power of running water and its contained sediment both sideways and downwards, it belongs to the ideas of the paradoxers who do not yet revere the name of De Morgan. There are some people who will not see what others can. Amongst other paradoxes, the author tells us that the mud carried down by rivers is no proof of their erosive power.

The theory of sub-aerial denudation is a terrible trial of our author's faith; and because Stonehenge is where it was, and the turf lies and daisies flourish at the same level, century after century, in spite of wear and tear, therefore mountain outlines, valleys, and all the details of the physiographer, are not the result of the elements. This is a very old objection, but it is worth nothing; for whilst grass-covered spots last longer, others go with great rapidity, are worn down, furrowed, and make up the mud for the river and the sea. The evident accomplishments of the author of this work, his equally evident want of knowledge of the geology of the day, and his pinning his faith to "Manuals," are explanatory to a certain degree of his views, and of their appearing in print; but the real cause comes out in the last sentence. There we find the rattle in the tail; there the theological serpent, wise and even dove-like, shows its crest. Thus the author concludes: "The hunger of the mind to see every natural occurrence resting upon a cause, and the vanity of believing that modern science can account for and explain everything, appear to create in the scientific mind a stubborn resistance to the belief in a *First Cause*." This is not very consequent, and indeed is a gross mistake, to say the least: it is an unworthy

libel on a great number of men who probably have less anthropomorphic, but really nobler and grander ideas of the Creator of all things than "Verifier." Finally, we read, "It will eventually be acknowledged that, at the time and in the process of fashioning the globe, a power was exerted totally different from the present course of nature." We do not think that this prophecy will be fulfilled; on the contrary, we believe that the persistence of the influence of the primitive energies is true, and characteristic of the infinite wisdom which in the moral government of the world taught man not to bear false witness against his neighbour.

DERBYSHIRE IN PREHISTORIC TIMES.*

AS the circle of the sciences continues to enlarge, it comes in contact with subjects which were formerly considered to lie far outside its pale. Scientific methods are now-a-days applied to history, to mythology, and to almost all archæological subjects. Everything that relates to man in the past, when treated scientifically, is in fact fairly claimed as material for anthropological study. And the wholesome effect of this has been well seen in our increased knowledge of the early history of our own islands. The old-fashioned type of antiquary who was wont to attribute everything to the Romans is not, it is true, extinct, but he is certainly becoming rare. Geologists and craniologists have worked hand in hand with the archæologist, and their combined labours have been fraught with excellent results. Bone caves have been explored, and barrows have been opened, and an entirely new light has been thus shed upon the history of our "rude forefathers."

Mr. Rooke Pennington is an enthusiastic explorer of the prehistoric antiquities of the Derbyshire Peak, and takes much interest in the little museum at Castleton. In preparing a catalogue of the archæological part of this museum, he was led to jot down some notes on local antiquities, and these notes have grown into the volume before us.

Derbyshire has been rich in antiquarian explorers, among whom we may mention the names of Bateman, Carrington, and Llewellyn Jewitt. But there is plenty of room everywhere for those who really wish to assist in the interpretation of that mysterious Past which speaks only in the language of a flint arrow, or a bronze dagger, or a rude urn. Mr. Pennington has consequently been able to add something to our knowledge of this Past by his exploration of some of the barrows and caves in which Derbyshire abounds.

Both *long* barrows and *round* barrows are found in Derbyshire; and the former, we presume, are, as elsewhere, the more ancient. The long barrows formed the resting-place of a prehistoric race with marked dolichocephaly; and the Derbyshire tumuli thus conform to the famous anthropological dictum, "Long barrows and long heads; round barrows and round heads." The round or bowl-shaped barrows contain both burnt and contracted

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* "Notes on the Barrows and Bone Caves of Derbyshire: with an Account of a Descent into Elden Hole." By Rooke Pennington, B.A., LL.B., F.G.S. 8vo. London: Macmillan & Co. 1877.

burials, while the accompanying objects may be either of bronze or of stone, or of both materials. Our author has carefully analysed the results which were obtained by Bateman in his ten years' diggings, and has failed to detect any rule of association. The men of the neolithic and of the bronze age appear to have had the same customs, whatever ethnic differences may have distinguished them. We need hardly say that this conclusion runs counter to the opinion of most archæologists, such as Sir John Lubbock, who believe that, as a rule, cremation was practised in the bronze age, and that in neolithic times the body was buried in a contracted posture.

Cave-hunting forms an interesting part of Mr. Pennington's book. It was he who first called attention to the fissures in the Windy Knoll Quarry, which have yielded so rich an assemblage of pleistocene remains. From these fossils it is clear that herds of bison and reindeer must have roamed over the hills of Derbyshire in the pleistocene period, perhaps towards its close; or, as our author suggests with some vagueness, in "the late geological time." Professor Boyd Dawkins has studied this fauna, as also that from the Creswell Caves, which have been so carefully explored by the Rev. Magens Mello.* The Creswell fauna included the mammoth, the woolly rhinoceros, the cave hyæna, and the terrible sabre-toothed machairodus. With this assemblage of extinct animals, man must have lived—man in a state unquestionably savage, yet with some dawning desire for art. In fact, one of the most interesting relics of prehistoric man which have been found in any part of the country is a piece of bone from Robin Hood Cave, incised with the well-defined outline of the horse of the period.

So much indifference is often displayed by the inhabitants of a district to their local antiquities, that all enthusiastic exploration of this kind deserves encouragement. We only regret that Mr. Pennington did not see his way to illustrating his descriptions by a few engravings.

THE RECORD OF GEOLOGICAL LITERATURE.†

IN the early part of last year we noticed the appearance of the first "Geological Record," containing an account of the literature of geology and the affiliated sciences published in the year 1874. The second "Record," giving the analysis of the geological publications for 1875, is only just published, its appearance having been delayed in part by the occurrence of a fire at the printers', which, without absolutely destroying any portion of the work, threw obstacles in the way of its completion.

In our former notice we stated that, this series of annual volumes, if carried out, would prove a most valuable aid to the geologist, and the appearance of the second issue only serves to confirm and widen this opinion. In the new volume several improvements are introduced—some in the typographical execution of the work, to render it more easy to consult; one in the general arrangement, namely, the introduction of a heading "Oceania" for

* See an Article by Mr. Mello in our present number.

† "The Geological Record for 1875: an Account of Works on Geology, Mineralogy, and Palæontology, published during the year." Edited by William Whitaker, B.A., F.G.S. 8vo. London: Taylor & Francis. 1877.

those islands which do not readily admit of being grouped under other geographical categories: i.e. besides the Pacific Islands, to which the term is usually applied, such isolated spots of land as St. Helena, St. Paul, and Amsterdam island, but also including, erroneously it seems to us, such islands as Formosa, Japan, Sumatra, and Borneo, which the ordinary reader would certainly look for under the head of Asia; and, most important of all, the addition of a classified index of new species to the section devoted to palæontological contributions. To the working palæontologist this index will be an inestimable boon. It is classified only as far as the great zoological groups generally called classes, and under each of these the species are arranged in the alphabetical order of their generic names, so that all the difficulty that might easily arise from the adoption of a classification in more detail is avoided, and the palæontological student has merely to run down a column or two of names to see whether there is in the volume any record of a new fossil in which he may be interested.

The present volume is considerably larger than its predecessor, and includes, with the supplement for the year 1874, no fewer than 2,350 entries of papers and separate works published. The labour of preparing all these notices, most of which include a brief statement of the general contents or bearings of the works referred to, must have been very great, and the thanks of all geologists are due to Mr. Whitaker, the editor, and his staff of assistants, for carrying out to a successful issue so arduous an undertaking. We can only echo Mr. Whitaker's hope that the number of subscribers will increase sufficiently to enable him for many years to continue and even extend his valuable labours.

DIFFERENT FORMS OF FLOWERS.*

IT is a curious coincidence (though perhaps not without its appropriateness) that the grandson of Erasmus Darwin should be the great authority on what we may venture to call the "prohibited degrees of relationship" among plants. To the older naturalist it was an easy matter to discourse poetically upon the phenomena of the fertilization of plants, then but little known except to the professed botanist; but he might have felt his genius trammelled had he known anything of the wonderful series of restrictions upon indiscriminate fecundity which the persevering researches of his great descendant have brought to light.

In two numbers of this Review published during the present year we have had occasion to notice the appearance of works from Mr. Darwin's hand bearing upon this subject, namely, an original treatise upon "the effects of cross and self-fertilization in the vegetable kingdom," in which the general evidence from which it may be inferred that cross-fertilization is to be regarded as a necessary process, even in the case of hermaphrodite flowers, is brought forward; and a second edition of the wonderful book in which the cross-fertilization of the orchids is described. We have now before us a third volume, the contents of which scarcely yield in interest to those of

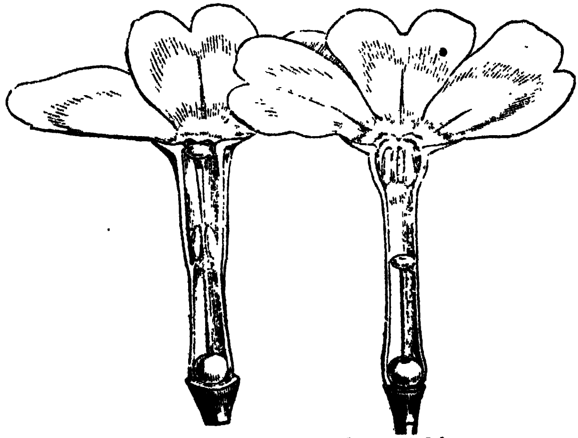
* "The Different Forms of Flowers on Plants of the Same Species." By Charles Darwin, M.A., F.R.S. 8vo. London: John Murray. 1877.

the second work above-mentioned, namely, the description of the different forms of flowers which occur on plants of the same species, with a discussion of the purpose served in Nature by these curious and sometimes complex arrangements.

The phenomena discussed in this volume have attracted Mr. Darwin's attention for many years, and very soon after the first publication of his "Origin of Species" (namely, in 1862) he communicated to the Linnean Society his first paper on the subject, which related to the dimorphism of the flowers in the genus *Primula.* Other papers followed on phenomena of the same order occurring in the genera *Lythrum* and *Linum*, and these constitute the foundation of a portion of the present work, in which, however, the author has added his own more recent observations upon other plants, and supplemented his personal work with information derived from many trustworthy sources. The whole constitutes a most interesting record of facts and inductions of great scientific importance; and the popular interest of the book is enhanced by the facility with which many of the observations may be repeated, so that anyone who has a garden and a magnifying-glass may with ease enter upon a course of practical investigation under the best possible guidance.

Mr. Darwin's first published researches related to certain species of the genus *Primula*, in the cultivated forms of which known as the polyanthus

FIG. 1.



Long-styled form. Short-styled form.

TWO FORMS OF FLOWERS OF THE COWSLIP (*Primula veris*), enlarged.*
The floral envelopes on the near side removed.

and the auricula florists have long been familiar with two kinds of flowers, which they denominate "pin-eyed" and "thrum-eyed." In the common cowslip (*P. veris*) this difference between the two forms is sufficiently remarkable (see Fig. 1.) In the "pin-eyed" plants the style is much elongated, so as to carry the nearly globular and rough stigma right up into the throat of

* For the loan of this and the following figures, we are indebted to the kindness of Mr. John Murray.

the flower, where it stands, like the head of a pin, far above the level of the anthers, which spring from the interior of the tube about half-way down. In the "thrum-eyed" plants, on the contrary, the anthers are placed quite in the throat of the flower; and the style, which is much shorter than in the preceding form, only carries the somewhat flattened and much smoother stigma about half-way up the tube of the corolla. In other words, the relative positions of the anthers and stigmas in the two forms are as nearly as possible reversed. For this difference in structure Professor Hildebrand long since proposed the term "heterostyled," which Mr. Darwin retains in the present work, although he gives the preference—justly, as it seems to us—to the term "heterogonous" proposed by Dr. Asa Gray, to express the same condition of the reproductive parts.

There are certain other differences in the two forms. Thus the long-styled plants have the pollen-grains smaller than those of the short-styled, and of an oblong form, whilst the pollen of the short-styled plants is nearly spherical; and further, the long-styled flowers have larger ovules and produce fewer seeds than their short-styled fellows. The two forms of flowers never occur upon the same plant, and the long-styled flowers seem to open a little earlier than the short-styled. The short-styled flowers are more fertile than the long-styled, the proportion of seed produced being by weight nearly as four to three.

To ascertain the meaning of these curious phenomena, which he naturally believed to point towards cross-fertilization, Mr. Darwin instituted a series of experiments on the cowslip, the results of which are very interesting. He covered with net six plants of the short-styled and eighteen of the long-styled form, and found that they produced respectively twenty-four and seventy-four umbels of flowers. The six short-styled plants furnished altogether about fifty seeds, weighing 1·3 grain, but not a single seed was produced by the eighteen long-styled cowslips. "Judging from the exposed plants which grew all round in the same bed," says Mr. Darwin, "and had been treated in the same manner, excepting that they had been exposed to the visits of insects, the above six short-styled plants ought to have produced ninety-two grains' weight instead of only 1·3; and the eighteen long-styled plants, which produced not one seed, ought to have produced above two hundred grains' weight. The production of a few seeds by the short-styled plants was probably due to the action of Thrips, or of some other minute insect."

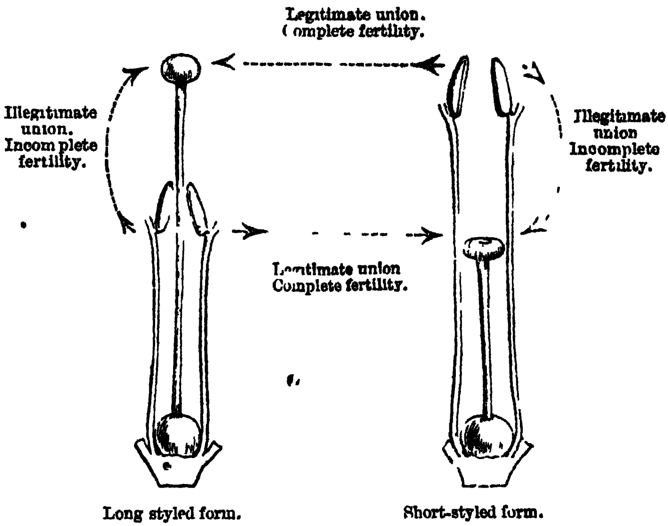
Thus we have insects again brought in as the marriage-priests of plants; and, considering the arrangement of the parts, as already described, in the cowslip, it is easy to see in what manner the visits of insects to the flowers are made available for this purpose. The flowers of the cowslip and of other species of *Primula* secrete an abundance of nectar, and bees and moths may be seen visiting them in search of this sweet food. Mr. Darwin records his observation of two species of humble-bees sucking out the nectar in a legitimate manner by inserting their trunks through the throat of the flower; Mr. H. Müller has seen an *Anthophora* and a *Bombylius* similarly engaged; and one of Mr. Darwin's sons caught *Cucullia verbasci* in the act. There is, indeed, no doubt that insects visit these flowers, and the mode in which their agency is made subservient to the fertilization of the different forms is

explained as follows by Mr. Darwin:—"The pollen," he says, "adheres to any thin object which is inserted into a flower. The anthers in the one form stand nearly, but not exactly, on a level with the stigma of the other; for the distance between the anthers and stigma in the short-styled form is greater than that in the long-styled, in the ratio of 100 to 90. This difference is the result of the anthers in the long-styled form standing rather higher in the tube than does the stigma in the short-styled, and this favours their pollen being deposited on it. It follows from the position of the organs that if the proboscis of a dead humble-bee, or a thick bristle or rough needle, be pushed down the corolla, first of one form and then of the other, as an insect would do in visiting the two forms growing mingled together, pollen from the long-stamened form adheres round the base of the object, and is left with certainty on the stigma of the long-styled form; whilst pollen from the short stamens of the long-styled form adheres a little way above the extremity of the object, and some is generally left on the stigma of the other form." That the two kinds of pollen are thus segregated in Nature was proved by microscopic examination of that adhering to the proboscides of the humble-bees and moth caught in the act of visiting the flowers, "and thus," says Mr. Darwin, "pollen will be regularly carried from the one form to the other, and they will reciprocally fertilize one another." Nevertheless, the pollen may occasionally reach the stigma even of the flower in which it was produced, and this seems to be especially the case with the short-styled form, in which Mr. Darwin found that when he "inserted a bristle or other such object into the corolla of this form, and had, therefore, to pass it down between the anthers seated round the mouth of the corolla, some pollen was almost invariably carried down and left on the stigma." By this means, and also by the visits of minute insects, such as Thrips, crawling into the tube of the flowers, a certain amount of self-impregnation is therefore possible; and indeed Mr. Darwin supposes this to have taken place in his early experiments in covering these plants, when, as already stated, the short-styled individuals produced a minute quantity of seed.

By a series of experiments in the fertilization of the stigmas of the two kinds of flowers by pollen from flowers of their own and of the opposite form, Mr. Darwin arrived at results which show clearly enough that the purpose of this peculiar arrangement of the parts is the assurance of cross-fertilization. He says "four essentially different unions are possible; namely, the fertilization of the stigma of the long-styled form by its own-form pollen, and by that of the short-styled; and the stigma of the short-styled form by its own-form pollen, and by that of the long-styled," the fecundation of the stigma by its own-form pollen being regarded by Mr. Darwin as an "illegitimate union," and by that of the other form as a "legitimate union," in accordance with the hypothesis which he had formed (see fig. 2). The tables showing the results of his experiments bear out his prevision in a remarkable manner. From them it appears that in the "legitimate" unions 77 per cent., in the "illegitimate" only 45 per cent. of the flowers fertilized produced capsules; 92·6 per cent. of the former and only 69 per cent. of the latter being what Mr. Darwin calls good capsules; that is to say, capsules containing more than one or two seeds; and the superior

fertility of the "legitimate" unions becomes still more striking when we find that the average weight of seed in good capsules from legitimate and illegitimate unions is as 54 to 35. Thus in this first series of experiments—the results of which, however, are perhaps a little below the average—the fertility of the legitimate and illegitimate unions, as shown by percentage

Fig. 2.



THE STAMENS AND PISTILS OF THE TWO FORMS OF COWSLIP, SHOWING THE FOUR POSSIBLE UNIONS OF THE POLLEN WITH THE STIGMAS.

results, in weight of seeds, would seem to stand approximately in the proportion of 38 to 11; or, in other words, the legitimate unions are 3½ times as prolific as the illegitimate ones.

The inference from these facts appears quite plain—the peculiar arrangement of the parts in the flowers of the cowslip is manifestly intended to insure the occurrence of cross-fertilization. The general facts must have been well-known to botanists for many years, seeing that the distinction of "pin-eyed" and "thrum-eyed" polyanthuses has long been recognized by florists; but their interpretation was a more difficult matter, and could only arise from considerations such as those put forward by Mr. Darwin in support of his much-maligned theory of evolution. As he says, we have here a case to which no parallel was known to exist in the vegetable, or indeed in the animal kingdom, for in this case the individual plants "are divided into two sets or bodies, which cannot be called distinct sexes, for both are hermaphrodites; yet they are to a certain extent sexually distinct, for they require reciprocal union for perfect fertility." But the clue once gained, the phenomena were soon found to be not at all isolated; and the researches of Mr. Darwin himself and of other observers have now brought to light a number of plants in which the same sort of dimorphism prevails. A majority of the species of *Primula*, certain species of *Linum*, several

rubiaceous plants, and some others, are found to exhibit similar characters; and these cases are all described in the work before us.

FIG. 8.

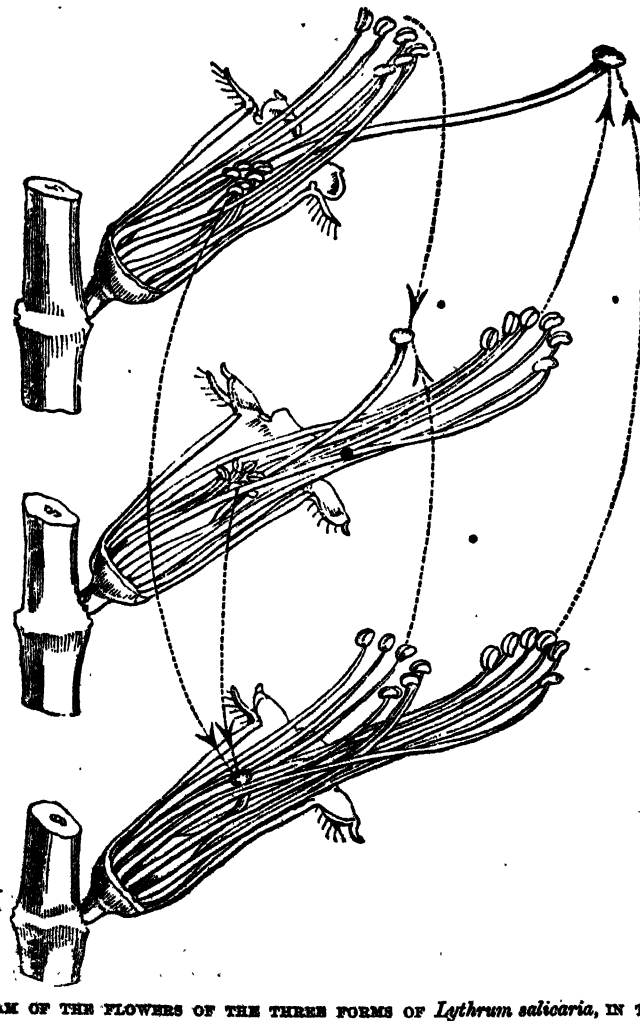


DIAGRAM OF THE FLOWERS OF THE THREE FORMS OF *Lythrum salicaria*, IN THEIR NATURAL POSITION, WITH THE PETALS AND CALYX REMOVED ON THE NEAR SIDE. ENLARGED SIX TIMES.

The dotted lines with arrow-heads show the direction in which the pollen must be carried to each stigma to insure full fertility.

The discovery of still more complex sexual arrangements in the Purple Loosestrife (*Lythrum salicaria*) was made by Mr. Darwin and described by him, soon after the publication of his observations on the

Primulaceæ. In this plant the flowers are trimorphic; that is to say, they exhibit three different proportions of the style and stamens. We have *long-styled*, *mid-styled*, and *short-styled* flowers, and each of these forms contains stamens of two different lengths (see fig. 3). In the long-styled form the style projects far beyond the six long stamens, which are of middle length, corresponding in this respect with the pistil of the mid-styled form, and protrude, with the style, from the mouth of the flower: within the flower are six short stamens. In the mid-styled flowers the six long stamens are about as long as the style in the long-styled form, with the longest stamens in which the style corresponds in length, and the short stamens are again enclosed within the calyx. The short-styled flowers have the pistil entirely concealed within the flower, whilst both sets of stamens project from its opening and are respectively of the length of the longest stamens in the other two forms. By a series of experiments, far too complicated for us to attempt to give any account of them here, Mr. Darwin ascertained that the pollen from each of the three kinds of stamens is destined to fertilize the pistil of corresponding length; the fertility of the legitimate unions on this principle, "as judged by the proportion of the fertilized flowers which yielded capsules, is as 100 to 33; and judged by the average number of seeds per capsule as 100 to 46." But taking the average number of seeds per flower fertilized, the proportional fertility is as 71·89 to 11·03. As Mr. Darwin indicates, the peculiar arrangements of the parts in this plant also are specially adapted to the requirements of fertilization by the agency of insects.

Several other trimorphic species are noticed here, and the details of experiments made upon them tabulated. The experiments and tables are necessarily of a somewhat complicated description, seeing that in the case of a trimorphic plant of this kind six legitimate and twelve illegitimate unions are possible, and all these had to be tried in order to get at reliable results.

Side by side with these elaborate provisions for securing cross-fertilization it is somewhat singular to find that in some species of plants there prevails a dimorphism which serve a directly opposite purpose. A considerable number of plants (Mr. Darwin here gives a list of fifty-five genera including them) bear what have been called cleistogamic flowers, which never open at all, are more or less imperfect in their structure, and yet bear an abundance of seed by a process of self-fertilization. The object of this peculiar arrangement, which may be observed in common species of *Viola*, in the woodsorrel, and many other well-known plants, is, according to the author, the production of "an abundant supply of seeds with little expenditure;" and he adds, "we can hardly doubt that they have had their structure modified and degraded for this special purpose; perfect flowers being still almost always produced, so as to allow of occasional cross-fertilization," which he has proved to be possible. In some instances, also, of which one is furnished by the pansy (*Viola tricolor*), there are two forms of flowers, one much more conspicuous than the other, and adapted to cross-fertilization by insects; whilst the smaller flowers, although not closed, like cleistogamic flowers, are more or less modified to insure self-fertilization. In these cases the two forms of flowers are produced upon distinct plants.

Mr. Darwin's researches upon what he calls the illegitimate offspring of

his dimorphic and trimorphic plants proved them to behave very much after the fashion of hybrids between distinct species; and this leads him to discuss the question of hybrids at some length, and more especially the hybrids of the species of *Primula*, which are numerous even in a state of nature. He also notices the peculiarities of monœcious, diœcious, and polygamous plants, of which he maintains that, "as the separation of the sexes would have been injurious, had not pollen been already transported habitually by insects or by the wind from flower to flower, we may assume that the process of separation did not commence, and was not completed, for the sake of the advantages to be gained by cross-fertilization. The sole motive for the separation of the sexes," he adds, "which occurs to me is, that the production of a great number of seeds might become superfluous to a plant under changed conditions of life; and it might then be highly beneficial to it that the same flower, or the same individual, should not have its vital powers taxed, under the struggle for life to which all organisms are subjected, by producing both pollen and seeds." This explanation is hardly satisfactory, and does not apply at all to monœcious plants. Among polygamous plants Mr. Darwin distinguishes a sub-class which he calls "gyno-diœcious," in which the unisexual flowers are all females, and he says that they yield a much larger supply of seed than they would have done if they had all remained hermaphrodites—in other words, fewer stamens than would exist in the flowers if all were hermaphrodite are capable of producing sufficient pollen for all their pistils. This is probably true also of the ordinary monœcious and diœcious plants, but still we cannot see where the necessary saving of material or powers comes in with sufficient force to account for phenomena of such importance. It must be borne in mind, however, that these suggestions of Mr. Darwin's are merely tentative, and that we have still much to learn before the "why and wherefore" of all these things is laid open to our view.

Nevertheless by works such as this, chiefly inspired by the new spirit thrown into natural-history research by the Darwinistic publications, we cannot doubt that progress is being made in the right direction. Any attempt at the explanation of phenomena is a step towards the truth; if it justifies itself it is absolutely an advance; if its justification be difficult, partial, or even impossible, the researches necessary for testing its value must in any case lead to valuable results. Even the steps taken apparently on the most indisputable grounds may open questions that it is very difficult to answer. Thus, to take the case of the Primulas, many species of which, as we have seen, seem to be specially organized so as to render cross-fertilization a necessity, we find, side by side with the "heterostyled" species, others which are "homostyled;" and it is hard to see, from the conditions of existence of the plants, why one set should be so peculiarly modified, and the other set left in what we may call a normal condition. So also with the monœcious and diœcious plants in groups the flowers of which are normally hermaphrodite. These and many other matters of doubt, which may easily occur to the mind in studying Mr. Darwin's descriptions of the different forms of flowers, furnish objects of study which we recommend to the attention of our readers; they are points not very difficult of investigation under the guidance to be obtained from

the present book, and their investigation certainly possesses a much higher interest for the botanist than the mere collecting, drying, and naming of the plants of his district.

DUST.*

"PHILOSOPHERS have said that 'there is a reason, a meaning, and an end in Nature.' We Dusts require more than this—a proof of the reason, a result of the meaning, and a continuance of the end."

These are the opening words of Mr. Malet's preface to his "Incidents in the Biography of Dust," and we cannot but think that our readers would forgive us if, having read them, we had abstained from any further examination of the book. But, as Thackeray once hinted, there is a power of self-sacrifice in the editorial idiosyncracy, and we endeavoured to the best of our power to make out what the purpose of the little book might be. There used to be a phrase current (whether it is still extant we know not) which ran as follows: "Down with the dust;" and so far as we remember bore a signification not at all agreeable to the impecunious. Mr. Malet's watchword is, "Up with the Dust," which would sound much pleasanter if we could only make out what "Dust" is. But this is precisely the puzzle before us.

In his first introductory chapter, which, we believe, gives in the form of aphorisms the principles of his theory, Mr. Malet tells us, in the first place, "that the earth consists of air, water, and dust." He then gives us the curious piece of information that "air is composed chiefly of oxygen, hydrogen, and carbonic acid gases;" and after telling us something about water proceeds to say that "the dry land of the earth is dust;" and then that "dust is now chiefly composed of everything that grew or lived on the earth, mixed with the dust from which all things were created." Here we seem to see a glimmer of light, and that by dusts may be signified the non-aeriform constituents of the world; but a little further on this comfort is taken from us, and we are told that "there are gaseous and non-gaseous dusts." In the next paragraph we learn that "everything that lived or grew was composed of air, water, and dust," which sounds like a return to the former conception; and then that "these three elements therefore compose the earth," so that dust is one of the elements; but when we turn to Chapter V., which is headed, "The Birth of Dust," and in which, therefore, we justly look for something conclusive, we find ourselves all abroad again. The author, in his playfully humorous style, writing himself down a Dust, tells us "that the dusts have nothing to do with the beginning." "It is far within the limit of that horizon that we look for the birth of our ancestors. Long previous to this event heaven and earth were created; the waters were divided by the firmament. Light and darkness made the day and night. The second day, that comprehensible measure of incomprehensible time, had passed away; two measures of eternity had run out; all

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* "Incidents in the Biography of Dust." By H. P. Malet. Small 8vo. London: Trubner & Co. 1877.

that was done in these measures was done by law. Those laws gave direct proof of supremacy; they were infallible; they have continued from eternity till now. The three elements affected by the laws—earth, air, water—were composed of and divisible into many parts; each part, and the whole, were amenable to the laws." Thus dust is an element, and earth is an element; but dust is not earth, for it is of later origin; and there are three elements, not four. Is not this "admirable fooling?"

As far as we can understand it, the author's geological theory, founded upon dust, is a Neptunian one, and he is in strong opposition to what he regards as the undue Plutonism of modern geologists. At the same time it must be observed that he considerably exaggerates the extent of this Plutonism; and, after the manner of his kind, quotes over-strong, and perhaps hasty statements of opinion on the part of individual geologists, as if they constituted the accepted body of geological science. In this process, being able to select his points of attack, he naturally sometimes gets the best of it; and he is evidently a firm believer in the Shandean principle, that when you demolish your opponent's theory you thereby establish your own.

In Mr. Malet's system of the earth "air and water are active, dust is the passive element." The sun is the sole cause of heat—its heat and the cold caused (he says "gained") by its absence produce the circulation of air and water. This circulation produces force, which acts on dusts, which are thereby moved on dry land and in the water. These movements cause subtractions on the surface and on the water bed, which are consequently lowered in places, and the surface of the water is therefore always sinking (?) and dust is left high and dry. The three following aphorisms are curious:—"Mountains are caused by the sinking of waters. The sinking of waters is due to the sun. Mountains are therefore due to the sun." And in other parts of his book the author ridicules the idea of mountains being thrown up by any forces of upheaval, whether by the ejection of materials from the interior of the earth or by the crumpling of the crust in shrinking. All "sinkings, landslips, subsidences, fractures, earthquakes," are caused by the removal of subterranean dusts by water. Further, there are combustible and incombustible dusts, which undergo pressure by the law of gravitation, and this pressure condenses dust. "Dust condenses heat. Heat acts on the dusts. Combustible dusts ignite; gases expand. Condensed sunlight is set free. Eruptions ensue." And you have an explanation of volcanic action. "The sun," adds Mr. Malet, "is the root of these phenomena. The root of the sun is the Creator. The earth is as it is, because the elements have not forsaken 'His laws.'" The last axiom probably contains the greatest truth in the book.

SCIENTIFIC SUMMARY.

ASTRONOMY.

DISCOVERY of Oxygen in the Sun.—Three interesting astronomical discoveries have been made during the past quarter. Undoubtedly the most important of these is the discovery of oxygen in the sun, by Dr. H. Draper, of New York. Although in some respects the discovery may be regarded as belonging rather to physics than to astronomy, yet its relation to the chief of all the bodies with which astronomy has to deal is too close to permit us to regard it as otherwise than astronomical.

Dr. Draper, who has been engaged now for several years in applying photography to the celestial bodies and their spectra (see our summary of astronomy for April last), in comparing the part of the solar spectrum between the lines G and H with the spectrum of air, finds that the oxygen lines are represented in the solar spectrum by bright lines. A well-marked quadruple oxygen line between wave lengths 4,345 and 4,350 coincides exactly with a bright group in the solar spectrum. This oxygen group alone is almost sufficient to prove the presence of oxygen in the sun, for not only does each of the four components have a representative in the solar spectrum, but the relative strength and the general aspect of the lines in each case is similar. On this point Dr. Draper remarks that he does not think sufficient stress has been laid on the general appearance of lines apart from their mere position ; in photographic representations this point is very prominent. Several other coincidences are noted, leaving no room for doubt that oxygen exists in the sun in such a condition that its lines appear bright in the solar spectrum instead of dark like the lines of sodium, of iron, &c., and (usually) of hydrogen. As to the existence of nitrogen in the sun, there is not yet certainty. "Nevertheless," says Dr. Draper, "even by comparing the diffused nitrogen lines of the particular photograph" selected for showing the oxygen coincidences, "in which nitrogen has been sacrificed to get the best effect for oxygen, the character of the evidence appears. The triple band between 4,240, 4,227, if traced upward into the sun, has approximate representatives. Again, at 4,041 the same thing is seen, the solar bright line being especially marked. In another photograph the heavy line at 3,995, which in this picture is opposite an insufficiently exposed part of the solar spectrum, shows a comparison band in the sun." The bright lines of oxygen in the solar spectrum have not hitherto been perceived, probably from the fact that in eye observation bright lines on a less bright ground do not make the same impression on the mind as

dark lines on a bright background. When attention is called to their presence they are readily seen, even without the aid of a reference spectrum. But the photograph brings them into greater prominence.

"The discovery of oxygen and probably other non-metals in the sun," says Dr. Draper, "gives increased strength to the nebular hypothesis, because to many the absence of this important group has presented a considerable difficulty." He accompanies his paper with a new theory of the solar spectrum, which he considers we must no longer regard as merely a continuous spectrum with certain rays absorbed by a layer of ignited metallic vapours, but as having also bright lines and bands superposed on the background of continuous spectrum. Such a conception not only opens the way to the discovery of others of the non-metals, sulphur, phosphorus, selenium, chlorine, bromine, iodine, fluorine, carbon, &c., but also may account for some of the so-called dark lines, by regarding them as intervals between bright lines.

New Star in Cygnus.—Second in importance only to the preceding, though probably it will be long before the true significance of the discovery is recognized, is the circumstance that the new star which blazed out last November in the constellation Cygnus seems to have faded into a nebula of the gaseous sort. "There is little doubt," says Lord Lindsay, in a letter to the "Times," "but that this star has changed into a planetary nebula of small angular diameter, giving a monochromatic spectrum when examined on Sept. 3, by means of a 15-inch refractor. The position of the star is R. A. 21 h. 36 m. 52 s.; N. Dec. 42° 16′ 53″; magnitude 10½, colour faint blue, near another star of the same size, rather red. A 5-inch telescope will render it visible; and the spectrum can be seen by means of a direct-vision prism outside the eyepiece. This would not be the place for speculating on the meaning of this most unexpected discovery, which indeed will require not only examination, but very careful examination and discussion, to educe its true significance. But without countenancing the statement that it is in direct opposition to the nebular hypothesis, we must admit that it runs directly counter to the theory that the planetary, or at any rate the gaseous nebulæ, are embryo suns.

Discovery of two Moons of Mars.—More interesting to the general public, because more readily intelligible, is the addition of two new satellites to the solar system, especially as these bodies are found in attendance on a planet which has long been regarded as moonless. On the night of Aug. 11, 1877, Professor Asaph Hall observed a small star near Mars, which was again observed on Aug. 16, when its motion was established by observation extending through an interval of two hours, during which the planet moved over thirty seconds of arc. On Aug. 17 this satellite was further watched, and an inner satellite detected, also by Professor Hall. On Saturday, Aug. 18, the discoveries were telegraphed to Alvan Clark & Sons, Cambridgeport, Mass., in order that if the weather should be cloudy at Washington, they might confirm the existence of the satellites with the 26-inch telescope for Mr. M'Cormick, now in their hands. The discovery was confirmed by Professor Pickering and his assistants at Cambridge, Mass., and also by the Messrs. Clark at Cambridgeport.

From the observations made up to Aug. 20, inclusive, Professor Newcomb

has derived the following approximate circular elements of the orbits. The probable errors assigned are only very rough estimates:—

The Outer Satellite.

Major semi-axis of apparent orbit, at distance [9·5930]	82″·5 ± 0″·5
Minor " " . .	27″·7 ± 2″
Major semi-axis of orbit at distance unity . .	32″·3
Position angles of apsides of apparent orbit . .	70°, 250° (± 2°)
Passage through the west apsis ($p = 250°$) . .	Aug. 19, 16 h.6, W.M.T.
Period of revolution	30 h. 14 m. ± 2 m.
Hourly motion in areocentric longitude . . .	11°·907
Inclination of true orbit to the ecliptic . . .	25° 4 ± 2°
Longitude of ascending node	82°·8 ± 3°

Position of pole of orbit on celestial sphere:

long. 352°·8	R.A. 316·1
lat. + 64·6	Dec. + 53 8

These elements give for the mass of Mars, one 3,000,000th of sun's.

The Inner Satellite.

Major semi-axis of apparent orbit, dist. [9·5930]	33″·0 ± 1″
Period of revolution	7 h. 38·5 m. ± 0·5 m.
Hourly motion in areocentric longitude . .	47°·11.
Passage through the eastern apsis ($p = 70°$) .	Aug. 20, 13 h. W.M.T.

It will be found, on comparing the position of the pole of orbit of the outer satellite with that of the pole of the Martian equator, as indicated in our paper on Mars in the July number, that the plane of motion of the outer satellite lies very near the plane of the Martian equator. Indeed, when we consider the nature of the observations by which the positions of both planes have been determined, we may fairly say that within the probable limits of error of observation these two planes are identical. From the elements given in the article on Mars, it will be seen that the R.A. of the pole of the Martian equator is assumed there to be 312° 4′, the north declination 50°·18′, according to which the two poles would be distant about 4° in R.A. and about 3½° in declination. The construction given in the above-named article will become strictly correct for the satellite orbit, in this or any future year (subject always to any change which may have to be made in the estimated elements, if, for N, 43°·9 be substituted, and for I (misprinted No. 1 in the article) 36°·2. As it is, the ellipse *e′e* represents with considerable correctness the nearer half of the orbit for the opposition of the present year.

The mass of Mars may be regarded as more correctly determined from the observations of the outer satellite during a few days, than from a century of observations and a mass of laborious computations on which Leverrier's masterly determination of the mass had been based. Since Leverrier determined the mass of Mars at one-2,968,300th of the sun's, it follows that the mass has been diminished by the difference between one-3,000,000th and

one-2,968,300th of the sun's mass, or approximately one-$\frac{121,700}{3,029,000}$th part of Leverrier's estimate, say one-25th of the 3,000,000th part of the sun's mass; or, since the earth's mass = one-350,000th part of the sun's, in round numbers, the reduction is equivalent to one-216th part of the earth's mass. We may say roughly that our estimate of Mars's mass must be diminished by one-200th part of the earth's mass, or by some 30 millions of millions of millions of tons.

Spectra of Comets b and c, 1877.—The spectrum of Winnecke's comet *b* 1877, examined with a Browning single prism spectroscope, by Copeland and Lohse of Lord Lindsay's observatory, was found to consist of three bright bands, closely resembling those of comet II., 1868, as figured by Dr. Huggins. The spectrum of comet *c* (Borelly's) was found also to consist of three bright bands, but not coinciding with those of the other comet. They seem to correspond with those seen by Huggins in the spectrum of Brorsen's comet of 1868, and comet I., 1871. The measures were all made with a spider line, or a steel cone, in either case feebly illuminated in an otherwise perfectly dark field. Lord Lindsay considers the steel cone the best, as it gives a broader line, and requires less illumination.

Two Flats on the Moon's Limb.—Dr. Ralph Copeland has recognized two remarkable "flats" on the moon's limb. The positive angles of their centres were found to be 264° 28′ and 272° 30′, their lengths being 1′ 39″·1 and 1′ 18″·2 respectively. They coincided sensibly with a spider line throughout their entire length. Assuming the lowest points to have been exactly on the moon's limb, these measures give the following results:—

	First Depression.	Second Depression.
Length in arc of moon's limb . .	5° 46′	4° 31′
Apparent depth	1″·24	0″·78
,, ,, in feet, about . .	7,200	4,500
Selenocentric latitude	− 14° 25′	− 6° 1′
,, longitude	+ 87 18	. + 86·41

It seems highly probable that these indentations are identical with two of those seen by Cooper Key on Sept. 6, 1863. Dr. Copeland, after comparing together various observations, comes to the conclusions that,—

The first depression is most probably caused by the presence of the adjoining ring-plains, *Ansgarius* and *Behaim*, on the moon's limb;

And that the second depression is undoubtedly a vertical section of *Kästner*.

Collective Light and Distribution of the Fixed Stars.—Mr. J. J. Plummer has endeavoured to determine the total illuminating power of the stars as compared with acknowledged photometric standards. He finds that the total illuminating power of all the stars above the horizon at one time is not less than one-eightieth part of the illumination due to the full moon. In dealing with stars of lower magnitudes, he is led to the conclusion that either Argelander's *Durchmusterung* contains many stars (more than one-third of the entire number) which, though rated as 9·5 magnitude, are sensibly below it, or else it must be assumed that at the average distance for stars of this magnitude a denser stratum actually exists, succeeded possibly by regions less fruitful beyond. "Having been led to the latter conclusion in

opposition to preconceived ideas," he "considers that the enormously increased ratio with which the numbers of the telescopic stars are multiplied is deserving of increased interest and continued discussion." A very brief study of Mr. Proctor's chart projection of Argelander's *Durchmusterung* shows that Mr. Plummer's conclusion, though not correct for the star-sphere as a whole, corresponds with what is observed over the region of the Milky Way.

Two new Inequalities in the Moon's Longitude.—In June 1876, a correspondent of the "English Mechanic" pointed out, over the signature "W. G. P.," two theoretical inequalities in the moon's longitude which had not hitherto been noticed, suggesting that they may possibly explain some actual inequalities observed in the moon's motion. "Some years ago I found," he wrote, on June 30, p. 405, vol. xxiii. of the "English Mechanic," "that there were two inequalities, due partly to the direct and partly to the indirect action of Jupiter; the one of which agrees very exactly in period, and the other very fairly so" with those mentioned ... They are:—

$$-1'' \sin \{(2-2i-c)t-2e+a\}$$

where i represents the mean motion of Jupiter, that of the moon being unity, and ·006306 being taken for that of i; also e and a are the mean longitude of Jupiter and of moon's perigee when $t=0$. "The period of the above is very nearly 27·434 days, which falls within the narrow limits 27·42 and 27·44, given by observation. It remains to be seen whether, besides this, 1″ represents pretty well the proper amount of the inequality at its maximum, and whether a maximum occurs at the proper time. With regard to the long inequality, it will be of the form—

$$p \sin \{(2-2i-2c)t-2e+2a\}$$

its period will be about 17½ years. That of the observed is given at 16⅔ years, with a probable error of half a year; and therefore with a possible error of eight months this would make it within the period of the calculated inequality." In later numbers these inequalities were discussed by "W. G. P." and by another skilful mathematician, W. C. Evans, who analysed their value, describing fully his method of procedure, and in particular explaining carefully, for a third correspondent, "N." (understood to have been Mr. Neison), certain difficulties under which "N." laboured. Nine months later these identical inequalities were submitted to the Astronomical Society by Mr. Neison, and so far claimed as his, that in a paper which appeared in the June number of the "Monthly Notices," Professor Newcomb, unaware of their prior discussion by "W. G. P." and Mr. Evans, speaks of them as "new inequalities in the moon's longitude pointed out by Mr. Neison." We would suggest to Mr. Neison's consideration that his procedure in this matter has been ill-considered. He has, we will assume, been able, directed as he was by the two mathematicians referred to, to recalculate these inequalities, with closer approximation to their true value. Whatever credit may be due to him on this account would gladly have been accorded; the credit of noticing the inequalities he should not have claimed, for it is not his.

Rotation of Saturn.—Professor Hall, from observations of a white spot just below the ring of Mars, finds the planet's rotation-period to be

10 h. 14 m. 23·8 s. ± 2·30 s.

Sir W. Herschel's estimate was

10 h. 16 m. 0·4 s;

the estimate commonly described as his latest, viz. 10 h. 29 m. 16·8 s., never having been given by him at all, but being in reality Laplace's theoretical estimate of the period of the ring's rotation.

Phenomena for the Quarter.—The most interesting phenomena during the next quarter will undoubtedly be the close approach of Mars and Saturn, at 4 A.M. on Nov. 4: Mars will be 11′ north of Saturn. Neptune will be in opposition to the sun on Oct. 29, at 11 A.M. Venus will reach her greatest easterly elongation on Dec. 11. Mercury reaches his greatest westerly elongation on Oct. 12, his greatest easterly elongation on Dec. 25.

CHEMISTRY.

Davyum.—Sergius Kern, of St. Petersburg, has sent to the "Comptes rendus," 1877, lxxxv. 72, a short notice on the occurrence of a new metal belonging to the platinum group, to which he has given the above name. The new element occurs in a specimen of native platinum, doubtless from a Russian locality; it is not stated, however, whence it was derived. The material which he had to work upon possessed the following composition:—

Platinum	80·03
Iridium	9·15
Rhodium	0·61
Osmium	1·35
Palladium	1·20
Iron	6·45
Ruthenium	0·28
Copper	1·02
Davyum	0·045
	100·135

600 grammes of the native alloy were treated by the method devised by Bunsen for the separation of the metals, and the mother-liquors remaining after the removal of rhodium and iridium were treated with an excess of ammonium chloride and nitrate; a dull red-coloured precipitate was formed by these reagents, and when calcined it left a grey mass resembling spongy platinum. When heated in the flame of the oxyhydrogen blowpipe it fused together, forming a little bead, having the colour of silver and weighing 0·27 gramme. This is the new metal, which is stated to be hard at ordinary temperatures and malleable at a red heat, and to possess the specific gravity of [illegible]·385 at 25° C. Davyum is easily acted upon by aqua regia, but resists in a marked degree the action of boiling sulphuric acid. Potash throws

down a yellow precipitate, and sulphuretted hydrogen causes the separation from an acid solution of a brown sulphide, which is black when dry. Potassium sulphocyanide strikes a red colour in dilute solutions of the chloride: a feature which, as Kern points out, the new metal possesses in common with iron. The author does not refer to the fact that solutions of ruthenium exhibit the same reaction, so that it can hardly be referred to as a characteristic property of his new element. He believes, on what grounds we are not told, that davyum is the hypothetical element which in Mendelejeff's classification is placed between molybdenum and ruthenium, in which case its equivalent would be 100. The results of his investigation of the chemical and physical properties of the new metal will be published in a few months, when it is to be hoped more characteristic reactions will have been studied.

The Occurrence of Hyposulphites in Human Urine.—Schmiedeberg and Meissner found hyposulphurous acid to be an almost constant constituent of the urine of the cat, and to be frequently present in that of the dog; Strümpell ("Zeitschrift für Anal. Chemie," 1877, xvi. 134) has now detected its presence in that of a patient suffering from typhus fever. He was led to search for this acid through his attention having been directed to an unusual reaction which the liquid exhibited with silver-solution, during a volumetric determination of the chlorine: a reaction which those who perform analyses of this kind would do well to study. In the case which he examined he found that 1·5 gramme of sulphur passed from the body every twenty-four hours in other forms than that of sulphate. Calculated as hyposulphite, it would amount to a daily yield of 2·25 grammes of that salt.

Preparation of Hydriodic Acid.—While writing that portion of his "Kurzes Lehrbuch der anorganischen Chemie" which treats of the preparation of this acid, Kolbe's attention was directed to the method given in the text-books of Fittig, Von Richter, and Roscoe and Schorlemmer, where the quantities of iodine and water employed appear to be far in excess of those required to enter into reaction with the prescribed amount of phosphorus. It is the custom in the Leipzig Laboratory to add, by slow degrees, to ten parts of iodine, placed in an atmosphere of carbonic acid, one part of common phosphorus; and to pour on the mixture of di-iodide and tri-iodide, after it has become cold, four parts of water. The application of a gentle heat causes the disengagement of abundance of hydriodic acid, which is not contaminated with free iodine. Kolbe tried the proportions recommended in the three text-books, and first suggested by Vigier, where fifteen parts of water are to be poured on one part of amorphous phosphorus, and twenty parts of iodine are to be gradually added; and he finds this method useless. When heat is applied, much water and little acid pass off, and that little is strongly coloured with iodine (*Journ. Prakt. Chem.*, 1877, xv. 172).

A New Carbo-hydrate in Milk.—Ritthausen has found in milk a carbohydrate which is not milk-sugar ("Journ. Prakt. Chem.," 1877, xv. 348). It occurs in small quantities only, and is easily soluble in water. Its solution forms with a small quantity of the copper reagent the well-known blue liquid; when boiled for a long time a little cuprous oxide is deposited. If the liquid be previously warmed with a little sulphuric acid, the application of a gentle heat is sufficient to cause a copious reduction. Alcohol throws

down a flocculent precipitate from an aqueous solution of the substance, when evaporated to dryness, either by the application of heat, or at ordinary temperatures over sulphuric acid, there is left a gum-like viscous residue, in which the granular non-crystalline substance can be recognized. This reaction shows that the body under consideration is not milk-sugar.

A Wine of Great Age.—Berthelot describes ("Comptes rendus," 1877, lxxxiv. 1060) a wine, probably fifteen or sixteen centuries old, which was found in a sealed vessel of glass at Aliscamps (*Campi Elysei*), near Arles, and has been preserved in the Musée Borely at Marseilles. The glass vessel, which is figured in his paper, possesses a very curious form, and displays the etched, corroded, and iridescent appearance of glass of extreme age. The yellow liquid, which nearly filled the vessel, possessed a vinous odour, was distinctly aromatic, and recalled the characters of a wine which had been in contact with fatty bodies; the flavour was hot and strong, due to the presence of alcohol, acids, and a trace of aromatic substance. The composition per litre was found to be—

Alcohol	45·0 c. c.
Fixed acids, estimated as free tartaric acid .	3·6 grammes.
Bitartrate of potash	0·6 „
Acetic acid	1·2 „

as well as tartrate of lime in quantity which could be recognized, and traces of acetic ether. A trace of sugar, or rather of a substance which could reduce cupro-potassic tartrate, was recognized.

Solubility of Sulphur in Acetic Acid.—Liebermann ("Wien. Anz." 43, 1877) finds that sulphur is soluble to no inconsiderable degree in warm concentrated acetic acid, and that a trace is taken up even by the dilute acid. If the concentrated solution be diluted with water, much of the sulphur separates as milk of sulphur; if it be evaporated with the Sprengel pump, fine long prisms of sulphur separate; when cooled, moreover, the liquid deposits sulphur in a crystalline form. All modifications of the element appear to be taken up by acetic acid. The author refers to analytical methods where these changes occur, and are apt to mislead the operator.

A Red Colouring Matter accompanying Chlorophyll.—Harsten obtained two colouring matters from chlorophyll: a carmine (purpurophyll) and a yellow (chrysophyll). Bougarel has discovered ("Bull. Soc. Chim.," Paris, xxvii. 442) another colouring substance, which occurs associated with chlorophyll in the fresh and young leaves of many plants. Leaves of the peach were treated with ether until all the chlorophyll had been removed, and then they were directly digested with alcohol. After the lapse of two days the sides of the vessel and the surface of the leaves were covered with small brilliant crystalline plates, which exhibit the green hue of fuchsine by reflected light; by transmitted light they show a fine red colour; certain of them were observed under the microscope to have the crystalline form of uric acid. They are insoluble in water and nearly insoluble in potash, acetic acid, hydrochloric acid, alcohol, and ether; they are, however, readily taken up by chloroform and benzol, to which they impart a yellow tint, and in carbon disulphide, which they colour red.

Emodin.—Liebermann and Waldstein have isolated a crystallized product

from the bark of the buckthorn (*Rhamnus frangula*) by treating it with dilute soda solution ("Ber. deut. Chem. Gesell.," ix. 1775). An analysis of the purified substance gave numbers corresponding with the formula $C_{15}H_{10}O_5$, which Liebermann has shown to be that of emodin, first obtained by De La Rue and Muller from rhubarb root. The bark of the buckthorn contains about 0·2 per cent. of this substance. When distilled with zinc powder it yields a mixture of anthracene and methyl-anthracene. Whether frangulinic acid also exists in this bark has not yet been determined.

The Phosphorescence of Organic Compounds.—Radziszewski finds that formic aldehyde and grape sugar, when mixed with an alcoholic solution of potash, and warmed in presence of air, become phosphorescent ("Beiblatter Ann. Physik und Chemie," 1877, i. 242). As Duchemin has noticed that *Noctiluca milicris* can produce a burning sensation on the skin, it appears possible that it may secrete formic aldehyde, which changes in presence of oxygen to formic acid. The phosphorescence noticed in the case of grape sugar is a further indication of the probability of its being of the nature of an aldehyde. Neurine, which does not form aldehyde under similar circumstances, is not phosphorescent.

Action of Carbonic Acid.—Mohr has called attention ("Annalen der Chemie," clxxxv. 286) to a number of apparently anomalous decompositions produced by carbonic acid, in which stronger acids, such as phosphoric acid, acetic acid, and chromic acid, are expelled from their compounds by means of carbonic acid.

GEOLOGY AND PALÆONTOLOGY.

A Gigantic American Dinosaur.—The Cretaceous deposits of Colorado have lately yielded portions of a Dinosaur, which would appear to have exceeded in magnitude any terrestrial animal of which we have any knowledge. Professor Marsh descibes it ("Silliman's Journal," July, 1877,) under the name of *Titanosaurus montanus.* The most characteristic parts preserved are the last two sacral vertebræ, with their transverse processes, and portions of the posterior limbs. The vertebræ are remarkable as having such deep concavities as materially to lessen their bulk, in which they somewhat agree with those of *Eucamerotus* or *Streptospondylus,* described by Mr. Hulke; but in some of the vertebræ, at any rate, there are cavities in each side, which communicate with the surface of the vertebræ through a foramen opening below the base of the neural arch. These cavities the author believes to be pneumatic. From the measurements of the parts preserved Professor Marsh estimates the length of the entire animal at from 50 to 60 feet, and he believes it to have been herbivorous, and a distant ally of the small *Hadrosaurus agilis,* the only Dinosaur hitherto found in the Cretaceous of Kansas.

A Carboniferous Hexactinellid Sponge.—Mr. Carter has called attention ("Ann. Mag. Nat. Hist.," Sept. 1877) to the occurrence in the lower Carboniferous Limestone of Dalry, Ayrshire, of fossilized portions of a sarco-hexactinellid sponge, allied to *Hyalonema.* The fossils consist of spicules and fragments of spicules, among which are "the hexactinellid spicules of the body *in situ,* the long linear anchoring spicules, in at least

three specimens of the 'lash' or 'glass-cord' *in situ*, and fragments of the fluked ends of the anchoring spicules of the same lash, probably, but *separate*," thus furnishing all the skeleton-spicules that a hyalonematous sponge could present. The flesh-spicules, from their minuteness, could hardly have been preserved. The author is of opinion that probably the fossils described under the name of *Acanthaspongia*, McCoy, and *Protospongia*, Salter, are also remains of sponges of the same group as the above.

A new British Coral.—Professor Nicholson and Mr. R. Etheridge, Jun., have described ("Ann. Mag. Nat. Hist.," Sept. 1877) a new species of tabulate coral, which they refer to Professor Dana's genus *Tetradium*, the distinctive characters and affinities of which they discuss at considerable length. They come to the conclusion that *Tetradium* is most nearly related to *Halysites*, but with some affinities to *Chætetes*, thus forming a sort of connecting link between the two families of tabulate corals, the *Halysitidæ* and *Chætetidæ*. They notice two species of the genus:—the *Tetradium minus* of Safford, from the Silurians of the United States and Canada (Cincinnati and Hudson River Groups), and *T. Peachii*, a new species found in pebbles of Silurian limestone, contained in the Old Red conglomerates of Habbies How, in the Pentland Hills, near Edinburgh.

A Silurian Annelid.—Worm-tracks have been long known as almost the only indications of the existence of animals in certain very ancient rocks, but in these nothing more than the tracks have been detected, whilst in some fossiliferous deposits, the only traces of annelids have been of a similar nature. Mr. G. B. Grinnell now describes ("Silliman's Journal," Sept. 1877), some remains, apparently of Annelids, obtained by Mr. A. G. Wetherby, from Lower Silurian rocks near Cincinnati. He regards the bodies fossilized as probably the jaws of a worm allied to the existing genus *Nereis*. He describes the largest and most perfect jaw, which is rather more than a fifth of an inch long, as of a dark brown colour, hollow from the base throughout the greater part of its length, and having numerous denticulations (eight are preserved in the specimen) along its side. The anterior tooth is the largest and slightly twisted outwards; the teeth towards the base are deficient. He also notices another form, which bears eighteen teeth, of which the anterior is long and stout, the five following very small, and the remainder sharp and strong. This fossil is only half the length of the other, and the author seems inclined to identify it with one of the setæ of a nereiform worm.

A new Triassic Lizard.—Professor Oscar Fraas describes and figures ("Württemb. naturw. Jahreshefte, xxxiii. Heft. 3, 1877") a most extraordinary group of fossil reptiles, obtained from a sandstone quarry in the Middle Keuper, near Heslach. No fewer than twenty-four individuals of the same species were found in a slab of sandstone having a surface of about two square metres; the animals were beautifully preserved, and in some cases their attitudes are almost life-like, all the hard parts, including the bony dermal scutes, being there in their natural position. The effect of the group is increased by the fact that all these bony parts have become converted into vivianite, the blue tint of which contrasts wonderfully with the greyish colour of the stone. Professor Fraas describes this animal in great detail, and refers especially to certain bird-like characters presented by the

skull, which have led him to give the name of *Aetosaurus* (or eagle-lizard) to the new genus which he establishes for its reception. The teeth, which are inserted in distinct sockets, have a cylindrical root and a compressed, somewhat lance-shaped crown; the central cavity is very wide in the cylindrical root, but gradually narrows towards the point of the crown, during its passage through which it gives off numerous branched canals towards the periphery of the tooth. Professor Fraas regards this tooth as more like that of *Ptreodactylus* or *Rhamphorhynchus*, than of a lizard or crocodile. The whole body is covered with bony plates, as is also the long tapering tail. The systematic position of this reptile is rather difficult to determine. The author says that the bones of the skull and those of the extremities point sometimes to one, sometimes to another type of reptiles, whilst at the same time the bird-type peeps forth in the four perforations of the cranium, the perforation of the lower jaw, and the sabre-shaped shoulder blade. He is of opinion that *Aetosaurus* is probably one of those Ornithoscelida with lacertilian characters, the occurrence of which has been anticipated.

Archæopteryx.—According to a statement in the "Zoologische Garten," a second specimen of *Archæopteryx lithographica* has lately been obtained from the quarries at Pappenheim, near Solenhofen, where the only other known example of this singular bird was discovered some twenty years ago. The new specimen is said to be much more perfect than the former one, and especially to have the head entire.

Food of a Siberian Rhinoceros.—Dr. J. Schmalhausen has made a microscopical investigation of the fragments of food picked out of the cavities of the teeth of a Siberian *Rhinoceros antiquitatis* (= *tichorhinus*), preserved in the Museum at Irkutsk. He identified portions of grasses, and the small twigs of some woody plants, such as *Pinus picea*, *Abies*, *Larix*, *Betula*, *Ephedra* and *Salix*, and although he is not quite certain about the species, most of them closely resemble well-known plants still growing in high northern latitudes. This furnishes fresh support to the opinion, originally expressed by Brandt, that the rhinoceroses and other great pachyderms of Siberia actually lived at or close to the spots where their frozen bodies are now to be found.

The Quaternary Fauna of Gibraltar.—After long investigation, Professor Busk has communicated to the Zoological Society the results at which he has arrived from the examination of a large series of mammalia, from the ossiferous breccia of the caves of Gibraltar. These remains belong to a far more ancient fauna than that described by Professor Busk in a former paper; he refers them "in all probability to the early Pleistocene, if not Pliocene, epoch."

The following animals are recorded. A species of bear (*Ursus fossilis* or *arctos*), the spotted hyæna (*H. crocuta*), a leopard (*Felis pardus*), a lynx (*F. pardina*), a cat (*F. caligata*), the horse (*Equus caballus*), a rhinoceros (*R. hemitæchus*), two species of deer (one resembling the fallow deer, *Cervus dama*, the other probably *Cervus elaphus*), an ibex (*Capra hispanica*), an ox (*Bos primigenius?*), a wild pig (*Sus scrofa*), hares and rabbits, and a molar of *Elephas antiquus*. It is remarkable that no remains of the Gibraltar monkey (*Macacus inuus*) occurred in these deposits.

From these results Professor Busk draws the following conclusions. The rock of Gibraltar, after undergoing its last changes, but while still united to Africa, was covered with trees, and harboured numerous large mammals. Some of these species, such as the elephant and rhinoceros, are now extinct; and others, such as the spotted hyæna, now exist only in the southern part of Africa. The leopard and *Felis caligata* are no longer found in Europe, but the lynx and Spanish ibex still inhabit the mountains of Spain. The entire fauna exhibits purely African affinities, and the author infers from the occurrence of *Elephas antiquus*, *Rhinoceros hemitœchus*, the hyæna and the cats at this southern point of Europe, unmixed with northern forms, that those species probably made their way northwards through the isthmus formerly connecting Europe and Africa at this point.

METEOROLOGY.

The Heat Evolved by Meteorites in Traversing the Atmosphere.—M. Govi, in a note presented to the French Academy of Sciences ("Comptes rendus," Aug. 20), discusses this question. M. Schiaparelli has demonstrated that, in order to calculate the loss of velocity of a body penetrating the atmosphere, it is not necessary to know the law according to which the density of the air varies in the different strata of the atmosphere traversed, but only the barometric pressure at the two extremities of the course, or (what comes to the same) the weight of air displaced by the body the initial velocity of which is known. M. Schiaparelli has also ascertained that the velocity of meteorites varies between 16,000 and 72,000 metres per second. Taking 50,000 metres per second as an average velocity, M. Govi calculates that a meteorite penetrating vertically into the atmosphere with this initial velocity would have a velocity of only 28,968 metres per second on reaching the point where the barometric pressure is one millim., 5,916 metres at ten millims., 506 metres at 100 millims., and five metres per second at the level of the sea. Taking these figures as indicating the lowest effect producible on a meteorite by the resistance of the air, M. Govi calculates that the number of calories corresponding to the loss of *vis viva* of a meteorite of 14·66 kilogr. reaching the stratum of air where the pressure is scarcely one millim., would be 2,921,317, which would more than suffice to explain all the phenomena of light and heat, and all the mechanical effects produced by the penetration of a meteorite into the highest strata of our atmosphere. Even at an elevation where the barometric pressure is only 0·001 millim., the meteorite in question might already have developed 6,413 calories, and have become visible. This, according to M. Govi, explains the enormous elevation of some meteorites the distance of which from the earth has been measured.

Sun-spots and Storms.—Mr. Henry Jeula, of Lloyd's, has lately written to the "Times" indicating that there appears to be some connection between the prevalence of sun-spots and the number of wrecks posted annually in Lloyd's "Loss Book," and that this may constitute a further link in the evidence connecting sun-spots with the phenomena of weather. He derives his data from two complete cycles of eleven years each, extending from

1855 to 1876. He divides each series of eleven years into three periods, and finds that there are two minimum periods of four years at the beginning and end of each cycle, having between them a minimum period of three years.

MINERALOGY.

Uranocircite.—Weisbach has given this name ("Jahrbuch für Mineralogie," 1877, p. 406), to the interesting new member of the group of "uranium-micas" which occurs in quartz veins in the granite of Bergen, near Falkenstein, in Saxon Voigtland. It is remarkable for containing baryta in place of lime, as the following analytical numbers show:—

Uranium oxide	55·86
Baryta	14·57
Phosphoric acid	15·06
Water	13·99
	100·48

The percentage of baryta (14·57) differs but slightly from that required by theory (15·60). Uranocircite forms the fifth member of this interesting group. It is curious to find that half a century ago Berzelius detected the presence of baryta as well as lime in specimens of the "uranium-mica" of Autun, while later mineralogists have found lime only.

New Localities of Minerals in Scotland.—Professor Heddle, of St. Andrew's, has met with quite a number of minerals in a block of granite, which was being used for building purposes near Tongue, in Sutherlandshire. He recognized the presence of amazon stone (a variety of orthoclase felspar, of a bright green colour), in isolated and twinned crystals, cleavelandite, lepidomelane, pinite, fluorite, sphene, zircon, magnetite, ilmenite, allanite, smoky quartz, and a mineral which has been shown to be thorite passing into orangite. On a part of the surface of the block, about three square feet in area, twelve large crystals of amazon stone were seen, eight of these being unbroken and perfect; one crystal of this mineral attained the length of 15½ inches, and measured 10 and 8 inches in the other directions. The block appears to have come from Ben Laoghal, a few miles inland to the north-west.

Bunsenine.—This new mineral, a crystallised telluride of gold which occurs at Nagyág, and to which Krenner gave the name of *Bunsenite*, is now to bear the altered name of *Bunsenine*, as the former term had already been applied to a native oxide of nickel met with at Johanngeorgenstadt. Bunsenine occurs in small grey rhombic crystals on quartz. Its chemical constitution is not yet made known, but the analytical results obtained by Wartha will shortly be published.—*Annalen der Physik und Chemie*, 1877, i. 636.

Homilite.—A new rhombic or monoclinic mineral, to which this name has been given, has been found by Paijkull at Stockhoe, near Brevig, associated with erdmannite and melinophane. It has a black, or brownish-black

colour, a waxy or vitreous lustre, and when in thin flakes is feebly translucent. The hardness is 5·5, the specific gravity 3·28, and the analytical results point to the formula $3(CaO, FeO), 2SiO_2, BaO_3$, as representing its composition.—*Verh. Geolog. Vereins Stockholms*, iii. 229.

Sphaerocobaltite.—Weisbach has given this name to a new member of the calcite group occurring at Riechelsdorf associated with the beautiful mineral roselite. It is found in spheroidal masses, black on the exterior, but exhibiting on the interior the fine red colour of erythrite (cobalt arsenate hydrate). It possesses the specific gravity of 4·02 and the following composition:—

Cobalt oxide	64·25
Carbonic acid	35·75
	100·00

and is therefore a cobalt carbonate.—*Jahrbuch für Mineralogie*, 1877, 409.

PHYSICS.

The Telephone.—During the recent session of the British Association at Plymouth, the lion's share of attention was unquestionably given to the telephone. Wherever the instrument was to be exhibited—whether in the Physical or in the Mechanical sections, or at Mr. Preece's popular evening lecture—there were always crowded audiences eager to learn something about so novel an apparatus. At the *soirées*, too, the telephone stood above everything else as the centre of attraction; and knots of people were crowded round the instrument, anxious to converse with friends in distant apartments. The interest in this subject culminated in the arrival of Professor Graham Bell, the inventor of the "talking telegraph."

Mr. Bell is a native of Edinburgh, who emigrated to the New World, and settled first in Montreal, and afterwards at Boston. Following his father's profession as an elocutionist and teacher of the deaf and dumb, he had been led to study with great care the manner in which air is thrown into vibration by the vocal cords, and the way in which these vibrations are received by the organ of hearing. By experiments on a dead human ear, he conceived the possibility of throwing a membranous disc, or artificial drum, into a state of vibration by the voice, and of transmitting these vibrations along an electric wire. His early experiments, made five years ago, were the very reverse of successful; but by successive modifications he so improved the instrument that he was able to exhibit at the Centennial Exhibition last year a telephone worthy of Sir William Thomson's notice. It was to this instrument that the Glasgow professor referred when addressing the Physical section of the British Association at last year's meeting.

Since the close of the Philadelphia Exhibition, the development of the telephone has occupied Professor Bell's constant attention. Every part of the apparatus has been modified again and again, and even the instrument which he exhibited at Plymouth will probably be superseded in due course by improved forms. But in its present state—immature as the inventor

believes it to be—it is yet capable of rendering distinctly the words, or even the cough or sneeze, of a person thirty or forty miles distant. And the marvel of all this is greatly enhanced when one sees the extreme simplicity of the apparatus by which such extraordinary results are brought about. A small mahogany cylinder, which can be easily carried in the pocket, and is strongly suggestive of a stethoscope, contains all the mechanism; nothing indeed is visible outside except a mouthpiece at one end, and a couple of binding-screws at the other. Moreover, this modest little bit of apparatus serves equally for the transmitter and for the receiver of the sounds. You first speak through the mouthpiece, and then transfer it to the ear and listen for the reply. Even the interior of the wooden cylinder is simple in the extreme. Near to the mouthpiece there is a small disc of thin sheet-iron, which is thrown into vibration by the voice. These vibrations are executed in front of a soft-iron core attached to one pole of a permanent bar-magnet, and surrounded by a small coil of No. 38 silk-covered copper wire, one end of which is connected with the line-wire, while the other end communicates with the earth. The permanent magnet induces a magnetic field all round it, and attracts the iron diaphragm. When this disc vibrates, the condition of the magnetic field is affected, and a current is consequently induced in the coil; the strength of the current depending upon the amplitude and form of the vibrations. Each induced current traverses the line-wire, and passing through the coil of the receiving instrument, alters the magnetism of its core; thus increasing or diminishing its attractive effect on the iron disc, which is therefore thrown into a state of vibration. The vibrations of the receiving diaphragm are executed in perfect unison with those at the transmitting station, and consequently every sound uttered at one end, even to the nicest modulation of the voice, is reproduced at the other end.

Many of those who experimented with the telephone at Plymouth, and failed to get very audible replies, may have concluded that it is far from being a trustworthy instrument. But it should be borne in mind that Bell's instrument is so extremely sensitive, that when in connection with a telegraphic line, the currents along the neighbouring wires induce currents in the coils of the telephone, and the oscillating disc then produces a hum which almost overpowers the voice. In the United States, however, the apparatus is in practical use, instruments on Bell's principle being worked in New York, in Boston, and in Providence. At Plymouth verbal messages were sent from one part of the town to another; and in some of the deep Cornish mines conversation has since been carried on between the bottom of the shaft and the surface. Mr. Edison, of New York, has effected certain improvements in Professor Bell's apparatus; and Mr. Preece tells us that, with this improved form of telephone, words have been distinctly heard through a resistance equivalent to a distance of a thousand miles of wire. In the face of these results, no one will dare to say that oral telegraphy is not an accomplished fact.

While Bell's telephone is at present unique as an apparatus for the transmission of articulate speech, it need hardly be said that there are several other forms of telephone capable of transmitting musical notes, though not distinct words. Such, for example, is Mr. C. F. Varley's instrument, which

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has recently been working in London, and has conveyed musical sounds between the Canterbury Hall and the Queen's Theatre. Mr. Varley's invention dates back to 1870, when he patented a method, or rather several methods, whereby he could send rapid electrical undulations along an ordinary telegraph line, and reproduce these undulations as audible sounds at the other end. A tuning-fork, with one leg longer than the other, and having its shank connected with a battery, is caused to vibrate between a pair of electro-magnets. The vibrations generate momentary currents in the two primaries of an induction-coil, which are also connected with the battery. These currents in the primaries induce a succession of alternate currents or electric undulations in the secondary coil; and by means of a signalling-key these undulations are caused to alternately charge and discharge a condenser attached to the line. Hence a series of electric waves are caused to traverse the line, in unison with the vibrations of the fork. Or instead of the fork, a vibrating reed may be employed. The undulations which are thus transmitted are received at the opposite end of the line by an apparatus called a *cymaphen*, of which several different forms are described by the inventor. If the currents pass round a helix containing an iron rod, the latter is caused to vibrate; or if the coil contain a magnetized harmonium tongue, this in like manner will vibrate, and in either case musical sounds are produced. Again, if the currents circulate through a wire helix which encloses a hard-drawn iron or steel wire, stretched over bridges on a sounding board, the wire is magnetized whenever a current passes through the coil, and is alternately attracted and repelled by a pair of electro-magnets, one on each side of the wire; the vibrating wire then emits sounds similar to those of the oscillating tuning-fork at the transmitting station. Moreover, it is possible to obtain a musical note by the rapid charge and discharge of a condenser at the receiving end. In any of these ways audible sounds may be obtained, corresponding with the vibrations of a tuning-fork or of a reed at the distant end of a telegraphic line.

During the years 1874, 1875, and 1876, patents for various forms of telephone were obtained in this country by Mr. Elisha Gray, of Chicago. Without entering into the details of the mechanism by which the patentee sends a succession of electric impulses along a telegraphic line—as by the vibration of a series of tuning-forks of different pitch—it is sufficient to call attention to one extraordinary form of his receiving apparatus. This curious instrument is sometimes called the "physiological receiver," for reasons which will be obvious on explaining its action. It consists of a small cylindrical box of thin wood, with one face of sheet zinc slightly bulged out, and having an air-hole in the centre. The box is mounted on a horizontal axle, by which it can be rapidly rotated in a vertical plane. The electric current from the line passes, in most forms of this telephone, to the primary wire of an induction coil, and thence to the earth. One end of the secondary wire of this coil is connected with the axle of the receiver, and thence with the zinc face, while the other end of the wire is held in the hands of the operator. With one finger of that hand he presses upon the zinc disc, while he rotates the apparatus with the other hand. On the passage of an induced current, which is thus forced to pass through the body of the operator, who is in the secondary circuit, a distinct musical note is

emitted by the resonant box, corresponding with that of the vibrating fork at the transmitting station. A mere accident suggested in the first instance this remarkable form of apparatus, and the theory of its action still remains extremely obscure.

Whilst English and American electricians have thus been busying themselves with the telephone, the subject has by no means been neglected on the Continent. Thus M. Paul de la Cour, of the Meteorological Institute at Copenhagen, has constructed several forms of telephone, which have been successfully worked on some of the Danish lines. A tuning-fork is placed in a horizontal position, with its shank connected by means of a signalling key with the transmitting battery. On vibration of the fork, one leg comes in contact with a metallic spring, whereby connection is momentarily established with the line-wire. By rapidly making and breaking contact, a series of intermittent currents will be transmitted to the receiving instrument. This consists of a soft iron tuning-fork with each leg surrounded by a helix of silk-covered copper wire. On the passage of a current through the bobbins, the enclosed legs are magnetized. But in front of the legs are two electro-magnets, round which the current is also caused to circulate; and as it is so arranged that the legs acquire opposite polarity, attraction ensues, and the legs are consequently pulled out each time the current passes. The rapid movements thus produced by intermittent currents throw the surrounding air into vibration, and produce a note of the same pitch as that of the oscillating fork at the transmitting end of the line. If several instruments are employed, a number of distinct signals may be simultaneously transmitted along a single wire; for the intermittent current acts only on the particular fork which is in unison with that at the other end, and which is therefore competent to take up the vibrations.

As the telephone promises to become of great practical value, it is interesting to look back upon the earliest form of the instrument, and mark its relation to the later forms of apparatus. There can be no doubt that the oldest telephone is that which was invented in 1861 by Professor Reiss, of Friedrichsdorf, near Homburg. This is in fact the parent of all the recent telephonic brood. In using Reiss's instrument the operator sings through a mouthpiece into a wooden box, and thus throws into vibration a thin membrane, which is stretched across a large aperture in one side of the box. The membrane carries a small metallic disc connected with a battery, and every time this disc oscillates it comes in contact with a little platinum point attached to the wire of the telegraphic line. Contact is thus frequently made and broken, and a rapid succession of currents is consequently transmitted. The currents circulate around the helix of an electro-magnet at the receiving station, where they magnetize and demagnetize the enclosed bar more or less rapidly, according to the character of the note. But this rapid magnetization and demagnetization give rise to molecular changes in the bar, which produce a musical note: it is in fact the "galvanic music" which Page discovered in America forty years ago, but which remained unutilized until Professor Reiss suggested this application.

Although Reiss is fairly entitled to be called the inventor of the telephone, it is worth noting, as an historical curiosity, that the invention had been anticipated several years earlier. Dr. Paget Higgs has lately written to

"Nature," calling attention to a curious passage in the "Exposé des Applications de l'Electricité," by M. Le Comte du Moncel. In this work, dated 1857, the author refers to a friend's prediction of the possibility of transmitting speech by electricity, but regards it of course as simply a wild dream, scarcely worth mentioning. "Imagine," says this far-seeing friend, "that one speaks near a mobile plate, flexible enough not to lose any of the vibrations produced by the voice; that this plate establishes and interrupts successively the communication with a battery. You would be able to have at a distance another plate which would execute at the same time the same vibrations." Here then is a clear foreshadowing of the principle not merely of the tone telegraph, but of its highest development—the talking-telegraph. After all, there is nothing new under the sun—even in telephones.

A New Photometric Unit.—In comparing one source of illumination with another, it is of first importance to possess some standard unit by which the comparison may be made with scientific accuracy. To test the illuminating power of coal-gas, use is generally made of a photometric standard, which has been defined by Act of Parliament as a sperm-candle of six to the pound, consuming 120 grains of sperm per hour. For example: "14-candle gas" is gas which gives a light equal to fourteen of these standard candles. But it is impossible to get candles uniform in composition and in structure of the wick, while the amount of light which a given candle emits varies with the temperature and pressure of the surrounding atmosphere. Hence a good deal of uncertainty hangs over all photometric determinations. Mr. Vernon Harcourt, one of the Metropolitan gas-referees, has recently devised a new unit of light for photometric purposes, which he believes will satisfy all the conditions required for a trustworthy standard flame. The combustible used ought to be of definite chemical composition, burning under simple and definable conditions, and affected as little as possible by atmospheric changes. Mr. Harcourt's standard is a mixture of air with that portion of American petroleum which distils at a temperature not above 50° C. This liquid consists almost exclusively of pentane, the fifth member of the paraffin series. To form the standard mixture 600 volumes of air are mixed with one volume of the liquid pentane; the liquid rapidly volatilizes, and an uniform mixture of air and vapour is soon obtained. This combustible mixture is to be burnt from a ¼-inch orifice, at the rate of half a cubic foot per hour, under a temperature of 60° F. and a pressure of 30 inches of mercury. No change will be needed in the nomenclature of photometry, by the introduction of Mr. Harcourt's standard-flame; for the new unit is equal to the old ordinary sperm-candle unit, but much more constant and trustworthy.—*Chemical News*, Sept. 7, 1877.

Rain-bands in the Solar Spectrum.—By means of a miniature spectroscope, which can be carried in the waistcoat pocket, it seems possible to make rapid observations on the proportion of moisture in the atmosphere, and consequently to form a fair opinion as to the chance of coming rain. Professor Piazzi Smyth has described some interesting results of this kind, obtained during a recent journey from Edinburgh to Lisbon. The spectrum of daylight is examined through a spectroscope having a very fine and clean slit; and as it is necessary to look through a great thickness of atmospheric air, the instrument is directed to the sky nearest to the horizon. If the

atmosphere is highly charged with moisture, the aqueous vapour gives rise to a band of dark lines near the red end of the spectrum. A group of lines is very conspicuous, and may be termed the *rain-band*. This rain-band increases in strength in passing from colder to warmer climates. The information thus obtained spectroscopically is, in some sort, equivalent to that derived from the readings of the wet-and-dry bulb thermometers, and the subsequent calculations necessary to determine the hygrometric state of the atmosphere.—*Astronom. Reg.*, Sept. 1877.

Chromatic Aberration of the Eye, and Perception of Distance—No one now-a-days supposes that the human eye is a perfect optical instrument, at least in the sense in which an optician speaks of an instrument as perfect. The eye possesses, for example, decided chromatic aberration. Rays of light of dissimilar colour are not brought at once to an exact focus upon the retina, but each colour has its own focal distance. Let a red object and a blue object, of equal size, stand side by side, and it will be found that the images of these two cannot be in focus at the same time; therefore the two objects appear to be unequally distant, or of unequal magnitude. Hence estimates of distance founded on apparent magnitude are liable to be rendered fallacious by the colour of distant objects. And, on the other hand, estimates of distance founded on colour are liable to be confused by apparent magnitude. So far as our ideas of distance are dependent on the accurate focussing of rays upon the retina, it is evident that a source of error must be thus imported into the data of our perceptions. The subject has lately been very ingeniously handled by Mr. S. P. Thompson, of the University College of Bristol. He enumerates the various data for forming an estimate of distance which are dependent upon the eye, and not upon the limbs. After discussing the respective values of these data under various circumstances, he inquires how far they may be dependent upon the colour of an object, or upon the formation of an exact focus on the retina. Mr. Thompson concludes that the muscular sensation of adjustment of the eye to the focus of its lenses affords a possible means of estimating distances. When binocular methods, and those dependent on association of visible form and magnitude, fail, then the eye falls back upon colour as a means of effecting this. In fact, colour may in some cases outweigh the evidence of binocular vision. The chromatic aberration of the eye accounts for the well-known opinion of artists that blue is a retreating colour, and red an advancing colour. Aerial perspective is indeed a true expression of a physical fact in the perception of distance. Mr. Thompson's paper is interesting as offering a scientific explanation of certain empirical rules of artistic practice, relative to the expression of distance in painting.—*Philosophical Magazine*, July, 1877.

Diamagnetism of Hydrogenium.—When the late Professor Graham succeeded in charging palladium with hydrogen, or in "occluding" the gas so as to form what he regarded as an alloy of palladium and hydrogenium, he was puzzled with the anomalous magnetic behaviour of the new alloy. It is well known that palladium, like iron, is a magnetic metal; but it is believed that hydrogen is diamagnetic—that is to say, it is repelled instead of being attracted by the poles of a magnet. Hence it might be assumed, *à priori*, that the diamagnetic hydrogen would tend to neutralize the magnetism of the palladium, and that the alloy would consequently be less

magnetic than the palladium in a free state. As a matter of fact, however, this was found not to be the case. In short, the palladium charged with hydrogen was, according to Graham, *more* magnetic than in its ordinary state. Palladium is but feebly attracted by a magnet, but the hydrogenized palladium is much more powerfully attracted. The cause of the anomaly has been a fruitful source of dispute, and has led M. Blondlot to set to work and repeat Graham's experiments afresh, in order to see whether the discrepancy really exists. His results are in all cases diametrically opposed to those of Graham. In fact, he finds that the palladium, when charged with hydrogen, is *much less* attracted than when in a free state; thus showing that hydrogenium, like gaseous hydrogen, is diamagnetic. It is believed that Graham's curious results were due to impurities in the materials with which he experimented.—*Comptes rendus*, lxxxv. p. 68, July, 1877.

ZOOLOGY.

A One-armed Hydroid.—Under the name of *Monobrachium parasitum*, M. Mereschkowsky describes ("Ann. and Mag. Nat. Hist.," September, 1877), a most remarkable form of hydroid polyp discovered by him in the White Sea, where it lives at depths not exceeding five fathoms, adhering to the front end of the shell of the common *Tellina solidula*. The hydrorhiza in this singular polyp is represented by a sort of membranous expansion, from which the hydranths rise, and are surrounded for about one-fourth or one-fifth of their height by a chitinous tube, which the author regards as representing the hydrocaulus. The hydranth itself is a little, nearly cylindrical yellowish body, about one-twelfth of an inch long, truncated above, where it terminates in a simple rounded aperture. The single tentacle, which is filiform and very long, springs from one side of this primitive polyp-body a little above the middle. The gonophores or reproductive bodies are scattered among the ordinary hydranths, and spring, like them, from the membranous expansion. They have a short, thin stem, above which they are of an oval form, truncated above, and each of them develops in its interior a medusiform planoblast, having four radiating canals, each with two generative sacs, and sixteen tentacles. M. Mereschkowsky regards this hydroid as constituting the type of a distinct family of Athecata (Monobrachiidæ), nearly allied to the almost equally singular *Lar sabellarum* of Gosse, which possesses two tentacles. He points out that both these species, which are so scantily supplied with tentacles, take up their abode in peculiar positions—*Lar* upon the very margins of the tubes of *Sabellæ*, and *Monobrachium* upon one end of the shells of *Tellinæ*, in both cases in the spot where, by the exertions of the host, an abundant supply of nutriment will be brought easily within their reach. The great development of the tentacle in *Monobrachium* (it is three or four times as long as the body) he explains by the greater amount of nourishment which can be applied to the support of this single organ, coupled with the greater activity which it is obliged to display when compared with the tentacles of other hydroids. From a consideration of the characters of this and other hydroids, M. Mereschkowsky comes to the conclusion that the fundamental number in the hydroids is not four, as generally

supposed, but only two, so that the higher numbers exhibited in their tentacles and other organs are to be regarded as $2 \times n$, and he cites numerous examples which go far to establish his case. When uneven numbers occur, as in *Hydra*, for example, they are due to a certain amount of suppression or degradation; thus, *Hydra* would have $(2 \times 4) - 1 = 7$ tentacles. As the typical bitentaculate form, we have *Atractylis bitentaculata* cited, as in it the two tentacles are symmetrically placed; *Lar* as well as *Monobrachium* are to be regarded as degraded forms, the former having 6–4 and the latter 4–3 tentacles. The medusa of *Lar* is of a sex-radiate, and that of *Monobrachium* of a quadri-radiate type; and the remaining two tentacles in the former genus are not placed symmetrically, but at an angle of about 60° to each other.

Detection of Trichinæ.—M. Tikhomiroff suggests a new and easy method of detecting the presence of *Trichinæ* in suspected pork or sausages. The old method, consisting in the microscopic examination of slices of the suspected meat, may often lead to negative results, even when *Trichinæ* are present in abundance; the author proposes to isolate the muscular fibres, and states that their examination in this condition at once reveals the presence of *Trichinæ*. His process is as follows:—The flesh to be examined is cut with scissors into small fragments, soaked in distilled water, and then placed in a narrow-bottomed vessel with an approximately equivalent volume of chlorate of potash, and four volumes of concentrated nitric acid are added. The whole mass is then left for half-an-hour or more, and stirred occasionally with a glass rod. The fragments of muscle are then washed with distilled water, and put into a test-tube, one-third filled with distilled water, carefully corked, and shaken until the muscular tissue separates into its primitive bundles and fibres. The examination of these in a watch-glass, by the naked eye or with a lens, will immediately reveal the *Trichinæ* if present, as the fibres containing them at once attract the attention of the observer by the presence of fusiform swellings, whitish at the circumference, darker in the centre, along the primitive fibres. The microscope then easily tests the correctness of this rough investigation.—*Bull. Soc. Imp. Nat. Moscou*, 1877, No. 1.

The Colorado Beetle.—This malevolent animal still continues to occupy a good deal of the public attention, although, after the many false alarms that we have had, it is really hard to say how far the outcry in Europe is justified. The little scourge has been honoured by a discourse by Mr. McLachlan at the meeting of the British Association. That gentleman upholds an opinion which has been commonly expressed by entomologists, that the beetle, if it comes to us at all, will come in a chance fashion, by flying on board shipping at one of the American Atlantic ports, where it is now abundant. Dr. Andrew Wilson has written a small pamphlet on the insect, published by Messrs. W. & A. K. Johnston, and illustrated with enlarged figures of the true Colorado Beetle and the "Bogus Potato Bug;" this we have not seen, but we have been informed that it is good. —Messrs. Routledge have reprinted one of the admirable reports of Mr. C. V. Riley, of Missouri, from whose writings nearly all who have treated of the beetle have derived a very considerable part of their information. Enlarged drawings of the beetle may be seen stuck up in the windows of newspaper offices, &c., in various parts of the town, and our

publishers have produced an admirable large coloured figure of it, from the pencil of Mr. E. C. Rye.—Finally, Messrs. Stollwerck Brothers, of Cologne, have prepared wax models of the insect in all its stages, which, although not accurate in every detail, give an excellent idea of this pigmy bugbear.

Metamorphosis of the Dragon Fly.—According to a memoir presented to the French Academy of Sciences by M. Jousset de Bellesme ("Comptes rendus," August 20), the well-known enlargement of the body of the common dragon fly (*Libellula depressa*), and the expansion of its wings, soon after its emergence from the skin of the pupa, are effected in a rather singular manner. The author says that the animal *swallows* a great quantity of air and collects it in the intestine, which is thus greatly distended, filling almost the whole body-cavity and pressing the other organs against the skin. "Under the influence of this energetic pressure," he says, "the blood is driven forcibly towards the periphery, distends the eyes, and gives the head its definitive form; then, penetrating into the wing, between the two membranes which are separate up to this moment, it accumulates therein, unfolds it and circulates in it, depositing the pigment which is destined to colour it. At the same time the integuments, which are distended and bathed by the nutritive fluid, become coloured and acquire the solidity necessary for the insect." These statements are curious, if correct.

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